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A COMPUTER-BASED CASCADE IMPACTOR DATA REDUCTION SYSTEM

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Program Report

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J. W. Johnson, G. I. Clinard,
L. G. Felix, and J. D. McCain

Southern Research Institute
2000 Ninth Avenue, South
Birmingham, Alabama 35205

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Office of Energy, Minerals and Industry
Research Triangle Park, N.C. 27711

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SECTION 1

INTRODUCTION

Cascade impactors have gained wide acceptance as a practical means of making particle size distribution measurements. These devices are regularly used in a wide variety of environments, ranging from ambient conditions to flue gas streams at 400°C (752°F). Specially fabricated impactors can be used for more extreme conditions.

Because of their usefulness, the U.S. Environmental Protection Agency has funded research which has explored the theoretical and practical aspects of impactor operation. As part of this research, an effort has been made to design a comprehensive data reduction system which will make full use of cascade impactor measurements.

This publication describes a cascade impactor data reduction system designed to automatically reduce data taken with any one of four commercially available round jet cascade impactors: The Andersen Mark III Stack Sampler, the Brink Model BMS-11 (as supplied and with extra stages), the University of Washington Mark III Source Test Cascade Impactor, and the Meteorology Research Incorporated Model 1502 Inertial Cascade Impactor. Provision is not made in this system for reducing data taken with slotted jet impactors. With modification the computer programs can accomodate any round jet impactor with an arbitrary number of stages and with more extensive revision data can be reduced for slotted jet impactors.

The computer programs which comprise this data reduction system are written in the FORTRAN IV language. The plotting subroutines used were written specifically for the Digital Equipment Corporation (DEC) PDP-15/76 computer and these programs are not compatible with other plotting systems. However, these programs can be used as a guide when revision is made for use with another operating system.

The data reduction system is made up of six major (mainline) programs and 34 subroutines. Section 2 contains a broad outline of the functioning of each mainline program along with an explanation of the rationale for their design. The mainline programs and subroutines are discussed in detail in Section 3. Section 4 is a user's guide for each of the mainline programs. Detailed instructions for the input to each of the mainline programs is given in this section. Section 5 is a set of example calculations which are meant to be used in program checkout. An example of each kind of output that can be produced by this system is provided. Section 6 contains a complete program listing along with simplified flowcharts for the mainline programs. In an Appendix, a description is given of the plotter software used with the DEC PDP-15/76 computer system.

SECTION 2

GENERAL PROGRAM OUTLINE

In this section a broad outline of the program fundamentals is given with sufficient detail for anyone without a specialized knowledge of computers to understand the methods and rationale of the program. The program comprises two major blocks. The first block treats data from individual impactor runs while the second treats data from groups of runs, providing averages, statistical information and fractional penetration (efficiency) results. The overall program flow is shown in Table 1. For programming details, see Section 3 of this report.

INDIVIDUAL RUN DATA ANALYSIS

This portion of the impactor data reduction package utilizes impactor hardware information, particulate catch information, and sampling conditions from single impactor runs to calculate size distributions. The overall distributions are available in several forms. The run analysis and output presentation are accomplished by three main programs, MPPROG, SPLIN1, and GRAPH. MPPROG and SPLIN1 perform analysis and manipulation while GRAPH is totally devoted to various forms of graphical presentation of the calculated distributions. The routines used in GRAPH are specifically for use on a PDP-15/76 computer and are not compatible with most other computers without modification. However, the general structure of GRAPH should serve as a useful base for programming to achieve similar graphical output from other computing systems.

TABLE 1. PROGRAM FLOW

I. Impactor Program (MPPROG)

Takes testing conditions and stage weights to produce stage D_{50}'s, cumulative and cumulative % mass concentrations $<D_{50}$, geometric mean diameters, and mass number size distributions. Executed for each run.

II. Fitting Program (SPLIN1)

Uses modified spline technique to fit cumulative mass loading points for each plot. Stores fitting coefficients and boundary points on file. Executed for each run.

III. Graphing Program (GRAPH)

Produces individual run graphs with points based on stage weights and impactor D_{50}'s. Also superimposes plot based on fitted data, if desired. Graphs include cumulative mass loading, cumulative % mass loading, and mass and number size distributions. Can be executed as desired for each run.

IV. Statistical Program (STATIS)

Recalls cumulative mass loading fitting coefficients to produce average cumulative mass loading, average % cumulative mass loading, average mass size distribution, and average number size distribution plots each with 50% or 90% confidence bars. Executed for each group or data to be averaged.

Programs I-IV are used for both inlet and outlet data sets.

V. Efficiency Program (PENTRA) or (PENLOG)

Recalls average mass size distribution values along with 50% confidence limits for inlet and outlet to plot percent penetration and efficiency with 50% confidence bars. Executed once for each pair or group and used to define a fractional efficiency curve.

MPPROG

In MPPROG, sampling hardware information, sampling conditions and particulate catch information are used to determine the effective cut sizes of the various impactor stages and the concentrations of particles caught on these stages. The output is organized into several tabular forms and stored on a disk file for later use.

Input Data to MPPROG--

Because individual impactors, even of the same type, do not necessarily have precisely the same operational characteristics, the program calculates stage cut diameters on an impactor specific basis. Hardware data are stored within the program which include, for each impactor to be used, the number of stages, the number of jets per stage, the jet diameters, the stage calibration constants, and flow-pressure drop relations for each stage. Run specific input data to MPPROG are listed in Table 2.

Stage Cut Diameter (D_{50})--

The effective stage cut diameter is assumed to be equal to the particle diameter for which the stage collection efficiency is 50%. This diameter, D_{50}, is calculated from an equation of the form

$$D_{50} = k_s \left\{ \frac{\mu d}{\rho_p c v} \right\}^{\frac{1}{2}} \qquad (1)$$

where D_{50} = effective cut size (micrometers),
k_s = stage calibration constant,
μ = gas viscosity (poise),
d = jet diameter (centimeters),
ρ_p = particle density (grams per cubic centimeter),
c = Cunningham slip correction factor, and
v = jet velocity (centimeter per second).

TABLE 2. INPUT DATA TO MPPROG

1. Impactor identification (required to call up hardware information)
2. Fractional gas composition (CO_2, CO, N_2, O_2, H_2O)
3. Impactor flow rate (ACFM at stack conditions)
4. Stack pressure (inches of mercury)
5. Stack temperature (degrees Fahrenheit)
6. Gas temperature within impactor (degrees Fahrenheit)
7. Duration of sampling (minutes)
8. True density of particles (grams per cubic centimeter)
9. Maximum particle diameter present in sample (micrometers)
10. Masses of catches by stage (milligrams)

If the particle density, ρ_p, is set equal to the true density of the particles, the resulting diameter calculated from Equation 1 is the Stokes diameter, D_S. If ρ_p is set equal to 1.0 the resulting diameter is the aerodynamic diameter D_A as defined by the Task Group on Lung Dynamics.[1] If both ρ_p and C are set equal to 1.0, the resulting diameter is the aerodynamic impaction diameter, D_{AI}, as defined by Mercer.[2] Unless otherwise specified, MPPROG will automatically provide parallel output in terms of D_S and D_A. Parallel results in terms of D_S and D_{AI} or in terms of D_A and D_{AI} are available if called for.

Solution of equation 1 for D_S and D_A is executed in an iterative loop because the Cunningham slip factor, c, contains the particle diameter as part of its argument. The equations used for calculating μ and c are given below. These equations are adopted from J. A. Brink.[3]

$$c = 1 + \frac{2L}{D_{50} \times 10^{-4}} \left[1.23 + 0.41 \ \mathrm{EXP}\ (-.44\ D_{50} \times 10^{-4}/L) \right] \qquad (2)$$

D_{50} = particle diameter in micrometers

L = mean free path in cm

$$= \frac{2\mu}{1.01325 \times 10^{6} P} \left[\frac{\pi 1.38 \times 10^{-16} \times 6.02 \times 10^{23}\ T}{8\ M_G} \right]^{\frac{1}{2}} \qquad (3)$$

where μ = gas viscosity, poise,

P = gas pressure, atmospheres,

T = gas temperature, °K,

$M_G = f_1 44.10 + f_2 28.01 + f_3 28.02 + f_4 32.00 + f_5 18.02$, and

= wet mean molecular weight of gas.

where

f_{1-5} = wet gas fractions of CO_2, CO, N_2, O_2, and H_2O. The values of f_{1-4} are input to the program as dry gas composition fractions. Then $f_i = f_i\ (1.0 - f_5)$ to get wet fractions.

The gas viscosity, μ, is calculated in poise using an equation given by C. R. Wilke[4] from the gas composition and the viscosities of the individual pure gas components. The pure gas viscosities are calculated from polynomial fits to data in the Handbook of Chemistry and Physics (Forty-first Edition, Charles D. Hodgman, ed. Chemical Rubber Publishing Co., Cleveland, Ohio, 1959. pp. 2188-2192).

$$\mu = \sum_{i=1}^{5} \left[\frac{u_i}{1 + \frac{1}{f_i} \sum\limits_{\substack{j=1 \\ j \neq i}} (f_j \Phi_{ij})} \right] \times 10^{-6} \qquad (4)$$

$$\text{where } \Phi_{ij} = \frac{[1 + (u_i/u_j)^{\frac{1}{2}} (w_j/w_i)^{\frac{1}{4}}]^2}{4/\sqrt{2}\ [1 + (w_i/w_j)]^{\frac{1}{2}}} \qquad (5)$$

u_{1-5} = pure gas viscosities (gm/cm-sec)

u_1 = gas viscosity of CO_2 (6)

$= 138.494 + 0.499\ T_{CI} - 0.267 \times 10^{-3}\ T_{CI}^{2} + 0.972 \times 10^{-7}\ T_{CI}^{3}$

u_2 = gas viscosity of CO

$= 165.763 + 0.442\ T_{CI} - 0.213 \times 10^{-3}\ T_{CI}^{2}$ (7)

u_3 = gas viscosity of N_2

$= 167.086 + 0.417\ T_{CI} - 0.139 \times 10^{-3}\ T_{CI}^{2}$ (8)

u_4 = gas viscosity of O_2

$= 190.187 + 0.558\ T_{CI} - 0.336 \times 10^{-3}\ T_{CI}^{2} + 0.139 \times 10^{-6}\ T_{CI}^{3}$ (9)

u_5 = gas viscosity of H_2O

$= 87.800 + 0.374\ T_{CI} - 0.238 \times 10^{-4}\ T_{CI}^{2}$ (10)

where T_{CI} = temperature (°C)

f_{1-5} = wet gas fractions of CO_2, CO, N_2, O_2, and H_2O, respectively

w_{1-5} = molecular weights of CO_2, CO, N_2, O_2, and H_2O, respectively.

The local pressure at the inlet of each stage of the impactor is calculated by subtraction of the cumulative pressure drop through the impactor to the stage in question from the inlet pressure to the impactor proper.

$$P_s = P_o - (F_i)\ \Delta P \tag{11}$$

P_s = stage pressure (atmospheres)

P_o = impactor inlet pressure (atmospheres)

F_i = fraction of the total impactor pressure drop to the stage in question

ΔP = total pressure drop through the impactor stages (atmospheres)

The total pressure drop is assumed to be divided among the various stages in the same relative fashion for all impactors of a particular type, i.e., Brink. (This assumption ignores minor differences in jet diameters for a given stage among impactors of the same type.) The impactor is assumed to have a flow-pressure drop relation of the following form for a simple sharp edged orifice:[5]

$$\Delta P = K_I Q^2 \rho \tag{12}$$

K_I = empirically determined constant for each impactor type,

Q = flowrate through impactor (cm^3/sec),

ρ = gas density (gm/cm^3) at the impactor inlet.

Particulate Loading and Loading Breakdown Calculations--

This discussion is based on Table 3 which was generated by the computer program. In the example shown, the data were reduced using a particle density of 1.35 gm/cm^3; thus, the diameters reported are Stokes diameters.

Input information for each run is printed at the top of Table 3. The maximum particle diameter must be measured by examining the particles collected on the first stage (or first cyclone) with the aid of a microscope. Gas analyses must be

TABLE 3. SAMPLE CALCULATIONS

```
HYPOTHETICAL ANDERSEN                                                                                                    INPUT INFO
IMPACTOR FLOWRATE = 0,500 ACFM          IMPACTOR TEMPERATURE =  400,0 F = 204,4 C            SAMPLING DURATION =  20,00 MIN
IMPACTOR PRESSURE DROP = 0,3 IN, OF HG  STACK TEMPERATURE =  400,0 F = 204,4 C
ASSUMED PARTICLE DENSITY = 1,35 GM/CU,CM,   STACK PRESSURE = 26,50 IN, OF HG    MAX, PARTICLE DIAMETER = 100,0 MICROMETERS
GAS COMPOSITION (PERCENT)        CO2 =  1,94         CO =  0,00          N2 = 76,53          O2 = 20,53          H2O =  1,00
CALC, MASS LOADING = 8,0711E-03 GR/ACF       1,4748E-02 GR/DNCF        1,8470E+01 MG/ACM        3,3748E+01 MG/DNCM
IMPACTOR STAGE                        S1        S2        S3        S4        S5        S6        S7        S8      FILTER
STAGE INDEX NUMBER                     1         2         3         4         5         6         7         8         9
D50 (MICROMETERS)                  10,72      9,93      6,35      4,18      2,21      1,28      0,67      0,33
MASS (MILLIGRAMS)                   0,72      0,40      0,53      0,09      0,38      1,43      1,25      0,04      0,39      INPUT INFO
MG/DNCM/STAGE                   4,71E+00  2,62E+00  3,47E+00  5,89E-01  2,49E+00  9,35E+00  8,18E+00  2,62E-01  2,55E+00
CUM, PERCENT OF MASS SMALLER THAN D50  86,23  78,59  68,45  66,73  59,46   32,12      8,22      7,46                 CUMULATIVE
CUM, (MG/ACM) SMALLER THAN D50  1,59E+01  1,45E+01  1,26E+01  1,23E+01  1,10E+01  5,93E+00  1,52E+00  1,38E+00
CUM, (MG/DNCM) SMALLER THAN D50 2,91E+01  2,65E+01  2,31E+01  2,25E+01  2,01E+01  1,08E+01  2,77E+00  2,52E+00
CUM, (GR/ACF) SMALLER THAN D50  6,96E-03  6,34E-03  5,52E-03  5,39E-03  4,80E-03  2,59E-03  6,64E-04  6,02E-04
CUM, (GR/DNCF) SMALLER THAN D50 1,27E-02  1,16E-02  1,01E-02  9,84E-03  8,77E-03  4,74E-03  1,21E-03  1,10E-03
GEO, MEAN DIA, (MICROMETERS)    3,27E+01  1,03E+01  7,94E+00  5,15E+00  3,04E+00  1,68E+00  9,30E-01  4,75E-01  2,36E-01  DIFF
DM/DLOGD (MG/DNCM)              4,86E+00  7,93E+01  1,78E+01  3,24E+00  8,96E+00  3,95E+01  2,94E+01  8,56E-01  8,47E+00
DN/DLOGD (NO, PARTICLES/DNCM)   1,96E+05  1,02E+08  5,03E+07  3,35E+07  4,52E+08  1,18E+10  5,18E+10  1,13E+10  9,12E+11

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,
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made at the same time the impactor is run. The mass loading is calculated from the total mass of particles collected by the impactor and the total gas volume sampled, and it is listed in four different units after the heading CALC. MASS LOADING. The units are defined as:

GR/ACF - grains per actual cubic foot of gas at stack conditions of temperature, pressure, and water content.

GR/DSCF - grains per dry standard cubic foot of gas at engineering standard conditions of the gas. Engineering dry standard conditions in the English system are defined as 0% water content, 70°F, and 29.92 inches of Hg.

MG/ACM - milligrams per actual cubic meter of gas at stack conditions of temperature, pressure, and water content.

MG/DNCM - milligrams per dry normal cubic meter of gas at engineering normal conditions of the gas. Engineering dry normal conditions in the metric system are defined as 0% water content, 21°C and 760 mm of Hg (Torr).

Below these data the information pertinent to each stage is summarized in columnar form in order of decreasing particle size from left to right. Thus S1 is the first stage, S8 is the last stage, and FILTER is the back-up filter. If a precollector cyclone was used, a column labeled CYC would appear to the left of the S1 column and information relevant to the cyclone would be listed in this column. Beneath each impactor stage number is listed the corresponding stage index number, which also serves as identification for the stage. Directly beneath these listings are the stage cut diameters which were calculated as described previously. They are stage D_{50} values and are given in units of micrometers. The stage weights are likewise listed for the respective stages, labeled MASS, and are in units of milligrams. The mass loadings from each stage are labeled MG/DNCM/STAGE and are written in milligrams per dry normal cubic meter. They are calculated for each particular stage, j, by the formula

$$\text{MG/DNCM/STAGE}_j = \frac{\text{MASS}_j}{\text{SAMPLING DURATION (minutes)}}$$

$$\times \frac{\text{35.31 cubic feet/cubic meter}}{\text{FLOWRATE (ACFM)}} \times \frac{\text{Absolute Stack Temperature}}{\text{Absolute Standard Temperature}}$$

$$\times \frac{\text{Absolute Standard Pressure}}{\text{Absolute Stack Pressure}} \times \frac{1}{(\text{1-Fraction of } H_2O)} \qquad (13)$$

where absolute means the temperature and pressure are in absolute units-degrees Rankin or degrees Kelvin for temperature, and atmosphere, inches or millimeters of mercury for pressure, as appropriate. For S1,

$$\text{MG/DNCM/STAGE}_1 = \frac{.72\text{ mg}}{20\text{ min}} \times \frac{\text{35.31 cubic feet/cubic meter}}{\text{0.500 ACFM}}$$

$$\times \frac{(400 + 460)°R}{(70 + 460)°R} \times \frac{29.92\text{ in. Hg}}{26.50\text{ in. Hg}} \times \frac{1}{(1.0 - 0.01)} = 4.71\text{ mg/DNCM.}$$

The subscripts indicate stage index numbers.

The percentage of the total mass sampled contained in particles with diameters smaller than a particular D_{50} is called the CUMULATIVE PERCENT OF MASS SMALLER THAN D_{50}. It is the cumulative mass accumulated to the stage j divided by the total mass collected on all the stages, and converted to a percentage:

$$\text{CUM }\%_j = \frac{\sum_{i=j+1}^{9} \text{MASS}_i}{\text{Total Mass}} \times 100 \qquad (14)$$

For example, for S6, the cumulative percent is given by

$$\text{CUM }\%_6 = \frac{\text{MASS}_7 + \text{MASS}_8 + \text{MASS}_9}{\text{Total Mass}} \times 100$$

$$= \frac{1.25\text{ mg} + 0.04\text{ mg} + 0.39\text{ mg}}{5.23\text{ mg}} \times 100 = 32.12\%$$

For S8, the mass of the particulate matter collected on the filter is used,

$$\text{CUM }\%_8 = \frac{\text{MASS}_9}{\text{Total Mass}} \times 100 = \frac{0.39\text{ mg}}{5.23\text{ mg}} \times 100 = 7.46\%$$

The apparent errors in the least significant figures of the calculated percentages above as compared to those in Table 3 are due to using masses from the computer printout which have been rounded to two decimal places before printing.

The cumulative mass loading of particles smaller in diameter than the corresponding D_{50} in milligrams per actual cubic meter (CUM. (MG/ACM) SMALLER THAN D_{50})) for a particular stage j is given by the formula

$$\text{CUM.(MG/ACM)}_j = \frac{\sum_{i=j+1}^{9} \text{MASS}_i}{\text{sampling duration(min)}} \times \frac{\text{35.31 cubic feet/cubic meter}}{\text{FLOWRATE (ACFM)}} \qquad (15)$$

From the information at the top of the computer print-out sheet, the flowrate is 0.500 actual cubic feet per minute (ACFM) and the sampling duration is 20.00 minutes. Therefore, for S4,

$$\text{CUM.(MG/ACM)}_4 = \frac{\text{MASS}_5 + \text{MASS}_6 + \text{MASS}_7 + \text{MASS}_8 + \text{MASS}_9}{\text{20 minutes}} \times \frac{\text{35.31 cubic feet/cubic meter}}{\text{0.500 ACFM}} = \text{12.3 mg/ACM}$$

For S8, the mass of the particulate collected on the filter is again used,

$$\text{CUM.(MG/ACM)}_8 = \frac{\text{MASS}_9}{\text{20 minutes}} \times \frac{\text{35.31 cubic feet/cubic meter}}{\text{0.500 ACFM}}$$

$$= \frac{\text{0.39 mg}}{\text{20 minutes}} \times \frac{\text{35.31 cubic feet/cubic meter}}{\text{0.500 ACFM}}$$

$$= \text{1.38 mg/ACM}$$

The cumulative mass loading of particles smaller in diameter than the corresponding D_{50} in grains per actual cubic foot (CUM. (GR/ACF) SMALLER THAN D_{50})) for a particular stage j is given by the formula

$$\text{CUM.(GR/ACF)}_j = \frac{\text{CUM.(MG/ACM)}_j}{2.288\ \frac{\text{grams/cubic meter}}{\text{grains/cubic foot}} \times 1000\ \text{mg/gram}}$$

For S7,

$$\text{CUM.(GR/ACF)} = \frac{1.52\ \text{mg/ACM}}{2.288\ \frac{\text{grams/cubic meter}}{\text{grains/cubic foot}} \times 1000\ \text{mg/gram}}$$

$$= 6.64 \times 10^{-4}\ \text{grains/ACF}$$

The cumulative mass loading of particles smaller in diameter than the corresponding D_{50} in grains per dry normal cubic foot (CUM.(GR/DNCF) SMALLER THAN D_{50}) is calculated to show what the above cumulative would be for one cubic foot of dry gas at 70°F and at a pressure of 29.92 inches of mercury. For a particular stage j,

$$\text{CUM.(GR/DNCF)}_j = \text{CUM.(GR/ACF)}_j \times \frac{\text{Absolute Stack Temperature}}{\text{Absolute Standard Temperature}} \times \frac{\text{Absolute Standard Pressure}}{\text{Absolute Stack Pressure}} \times \frac{1}{(\text{1-Fraction of } H_2O)}$$

where absolute means the temperature and pressure are in absolute units-degrees Rankin or degrees Kelvin for temperature, and atmospheres, inches or millimeters of mercury for pressure.

For S1.

$$\text{CUM.(GR/DNCF)} = 6.96 \times 10^{-3}\ \text{GR/ACF} \times \frac{(400 + 460)^\circ R}{(70 + 460)^\circ R} \times \frac{29.92\ \text{in. Hg}}{26.50\ \text{in. Hg}} \times \frac{1}{(1.00-0.01)} = 1.29 \times 10^{-2}\ \text{GR/DNCF}$$

The particle-size distribution may be presented on a differential basis which is the slope of the cumulative curve.

Differential size distributions may be derived two ways:

1. Curves may be fitted to the cumulative mass distribution from which the differential curves (slope) for each test can be calculated. This method is described later.

2. Alternatively, finite difference methods may be used based on the D_{50}'s (abscissa) and the particulate masses on each stage (ordinate). This technique was used to generate the differential size distribution data in Table 3, and is described in detail in the following paragraphs.

If we define the terms:

ΔM_j = MG/DNCM/STAGE$_j$ and

$(\Delta \log D)_j = \log_{10}(D_{50_{j-1}}) - \log_{10}(D_{50_j})$ then

$$\left(\frac{\Delta M}{\Delta \log D}\right)_j = \frac{\text{MG/DNCM/STAGE}_j}{\log_{10}(D_{50_{j-1}}) - \log_{10}(D_{50_j})} \qquad (16)$$

Because the computer printer does not contain Greek letters, the computer print-out sheet reads DM/DLOGD instead of $\Delta M/\Delta$LOG D. For S6

$$\left(\frac{\Delta M}{\Delta \text{LOGD}}\right)_6 = \frac{9.35 \text{ mg/DSCM}}{\log_{10}(2.21) - \log_{10}(1.28)} = 39.4 \text{ mg/DNCM}$$

Note that $\Delta M/\Delta$LOGD has the dimensions of the numerator since the denominator is dimensionless. In the calculation for S1, a maximum particle diameter is used. For this example, MAX. PARTICLE DIAMETER = 100.0 microns.

$$\left(\frac{\Delta M}{\Delta \text{LOGD}}\right)_1 = \frac{4.71 \text{ mg/DNCM}}{\log_{10}(100) - \log_{10}(10.72)} = 4.86 \text{ mg/DNCM}$$

For the filter stage, the D_{50} is arbitrarily chosen to be one-half of the D_{50} for stage eight (S8). For this example, it is chosen to be (0.33 micrometers)/2 = 0.165 micrometers. Thus,

$$\left(\frac{\Delta M}{\Delta \text{LOGD}}\right)_9 = \frac{2.55 \text{ mg/DNCM}}{\log_{10}(0.33) - \log_{10}(0.165)} = 8.47 \text{ mg/DNCM}$$

The geometric mean diameter in micrometers (GEO. MEAN DIA. (MICROMETERS)) for a particular stage j is given by the formula

$$\text{GEO. MEAN DIA.}_j = \sqrt{D_{50_j} \times D_{50_{j-1}}} \qquad (17)$$

For S8,

$$\begin{aligned}\text{GEO. MEAN DIA.}_8 &= \sqrt{0.33 \times 0.67} \text{ micrometers}\\ &= 0.47 \text{ micrometers}\end{aligned}$$

As in the ΔLOGD calculation, we again use the maximum particle diameter for the stage one calculation and one-half the D_{50} of stage eight for the filter stage calculation.

For S1,

$$\begin{aligned}\text{GEO. MEAN DIA.}_1 &= \sqrt{10.72 \times 100.0} \text{ micrometers}\\ &= 32.7 \text{ micrometers}\end{aligned}$$

For the filter,

$$\begin{aligned}\text{GEO. MEAN DIA.}_9 &= \sqrt{0.165 \times 0.33} \text{ micrometers}\\ &= 0.23 \text{ micrometers}\end{aligned}$$

The finite difference methods used here result in values of $\Delta M/\Delta LOGD$ for the first stage of the collector and the backup filter which can have little physical meaning because of the large size intervals in LOGD covered by them.

A differential number distribution can also be derived. Since ΔM_j = MG/DNCM/STAGE$_j$ is the mass per unit volume for stage j then we can define ΔN_j = NUMBER OF PARTICLES/DNCM/STAGE$_j$ or the number of particles per unit volume for stage j. Now ΔM_j and ΔN_j are related by the equation $M_j = N_j \times m_p$, where m_p is the average mass of the particles collected on one stage. Dividing both sides of the equation by $m_p \times \Delta LOGD$ yields

$$\frac{(\Delta M/\Delta LOGD)_j}{m_p} = \left(\frac{\Delta N}{\Delta LOG\ D}\right)_j . \qquad (18)$$

Now $m_p = \rho_p V_p$ where ρ_p is the assumed particle density and V_p is the average volume of one particle on one stage. To obtain m_p in milligram units when ρ_p is in grams per cubic centimeter and V_p is in cubic micrometers, certain conversion factors must be used. The complete formula, using the correct conversion factors and the expression $(4/3)(\pi)(d/2)^3$ for V_p, where d is the geometric mean diameter in micrometers, is:

$$m_p = \rho_p \left(\frac{10^3 \text{ mg}}{1 \text{ gm}}\right) \left(\frac{4\pi}{3}\right) \left(\frac{d}{2}\right)^3 \quad \left(\frac{10^{-12} \text{ cm}^3}{1 \text{ cubic micrometer}}\right)$$

$$= (5.23599 \times 10^{-10})\ \rho_p d^3. \qquad (19)$$

Therefore,

$$\left(\frac{\Delta N}{\Delta \text{LOGD}}\right)_j = \frac{(\Delta M/\Delta \text{LOGD})_j}{5.23599 \times 10^{-10}\ \rho_p d^3}, \qquad (20)$$

where $\Delta M/\Delta$LOGD is in units of mg/DNCM, ρ_p is in gm/cm³, d is in micrometers, and $\Delta N/\Delta$LOGD is in number of particles/DNCM. For S3,

$$\left(\frac{\Delta N}{\Delta \text{LOGD}}\right)_3 = \frac{17.8 \text{ mg/DNCM}}{(5.23599 \times 10^{-10}) \times (1.35 \text{ gm/cc}) \times (7.94 \text{ microns})^3}$$

$$= 5.03 \times 10^7 \text{ particles/DNCM.}$$

For the filter stage

$$\left(\frac{\Delta N}{\Delta \text{LOGD}}\right)_9 = \frac{8.47 \text{ mg/DNCM}}{(5.23599 \times 10^{-10}) \times (1.35 \text{ gm/cc}) \times (0.231 \text{ microns})^3}$$

$$= 9.12 \times 10^{11} \text{ particles/DNCM}$$

SPLIN1

In many, if not most, sampling programs, a number of impactor runs will be made. Frequently, these runs will be made using several impactors, having different performance characteristics. The latter may be true even if the same type of impactor is used throughout a sampling program. This behavior results from manufacturing variations which cause calibration differences as well as run-to-run variations in sampling rates, which cause shifts in the D_{50}'s. Averaging results from such testing to obtain a representative composite size distribution requires that the distributions be broken down into like size intervals for all the runs to be averaged. The same requirement for like size intervals also holds for using inlet and outlet data from control device sampling programs to obtain fractional efficiencies. The program "SPLIN1" provides the ability to perform this required breakdown of the size distributions obtained from each impactor run into preselected uniform size intervals.

Before making the final selection of the spline technique, consideration was given to a number of alternate fitting methods, and several of them were tried. It was concluded that any attempt to fit a predetermined functional form (e.g. log-normal) to the data was generally not proper. Multimodal size distributions based on real data do not conform faithfully to the sum of these functional forms. Other non-linear forms were found unsatisfactory due to the high number of parameters needed to specify the fitting equation, especially those used on multimodal distributions. Because the slope of the cumulative distribution curve, the differential distribution, is the required quantity for calculating fractional efficiencies, consideration was also given to curve fitting the $\Delta M/\Delta \log D$ approximations of the true differential distribution, which was estimated directly from the stage loadings and D_{50}'s. However, the magnitude of the steps in D_{50} are large enough in most impactors as to frequently make $\Delta M/\Delta \log D$ a poor approximation to dM/DlogD. Moreover, the boundary conditions are more difficult to handle in fitting curves to ΔM/ΔlogD than in fitting to the cumulative distributions.

SPLIN1 operates by fitting a curve which is continuous in X and Y and the first derivative of Y with respect to X to the cumulative mass concentration size distribution data. The resulting fitted curve is similar to that which one would draw through the data points using a "French curve" or mechanical spline. This fitted curve invokes no *a priori* assumptions as to the shape of the distribution (*i.e.*, power law, log-normal, etc.).

Generation of Interpolated Points--

The technique used to fit the set of points defining the cumulative distribution curve is a modified spline procedure. The set of cumulative distribution points are used to define a set of interpolated points between each D_{50} value. A spline fitting procedure is then followed for the new set of original plus interpolated points. Initial attempts at using this technique on the set of points defining the cumulative distribution curve obtained directly from the D_{50}'s were not satisfactory. The difficulty occurred as a result of the inability of the method to generate sufficiently rapid changes in curvature when the curve to be generated was defined by a small number of points. A satisfactory fit could be obtained by adding a set of interpolated points between the original data points of the measured cumulative curve. These points are generated by means of a series of parabolas through consecutive sets of three adjacent data points of the actual cumulative curve defined at the D_{50}'s. The fitting is done using log (concentration) and log (particle diameter) as variables and begins with the segment containing the smallest D_{50} in the data set.

The sequence of operations by which the interpolated points are generated is shown in Figures 1. A series of parabolas are fitted through consecutive sets of 3 data points beginning at the smallest D_{50} as shown in Figures 1a and 1b. Three interpolation points are located along this parabola, between the lower pair of the three points used to generate the parabola. The three interpolated points are spaced evenly in log diameter between the pair of original points. A similar process is used to generate interpolated points between consecutive pairs of D_{50}'s up to the segment which terminates at the D_{50} of the first collection stage as illustrated in Figures 1c to 1e. A slightly different procedure which will be described later, is used for segments which include the first collection stage D_{50}.

Since the fitting is for a cumulative curve, a check is made for negative first derivatives of the interpolation parabola at the bounds of each segment within which the interpolated points are to be generated. If a negative derivative is found in any segment other than the first (the segment including the smallest D_{50}) a straight line interpolation between the segment bounds is used rather than parabolic interpolation. If a negative first derivative is found in the first segment to be fitted, a fictitous point is generated and used to form a parabola which has no negative derivatives in this segment. This fictitious point has the same concentration value as that of the first point on the cumulative curve and has a diameter defined by

$$D_{\text{fictitious}} = \frac{(D_{50} \text{ of last stage})^2}{(D_{50} \text{ of next to last stage})} \qquad (21)$$

The interpolated values for the segment between the last two D_{50}'s on the cumulative curve are then generated from the parabola which passes through this fictitious point, and the points for the last two stages on the cumulative distribution curve.

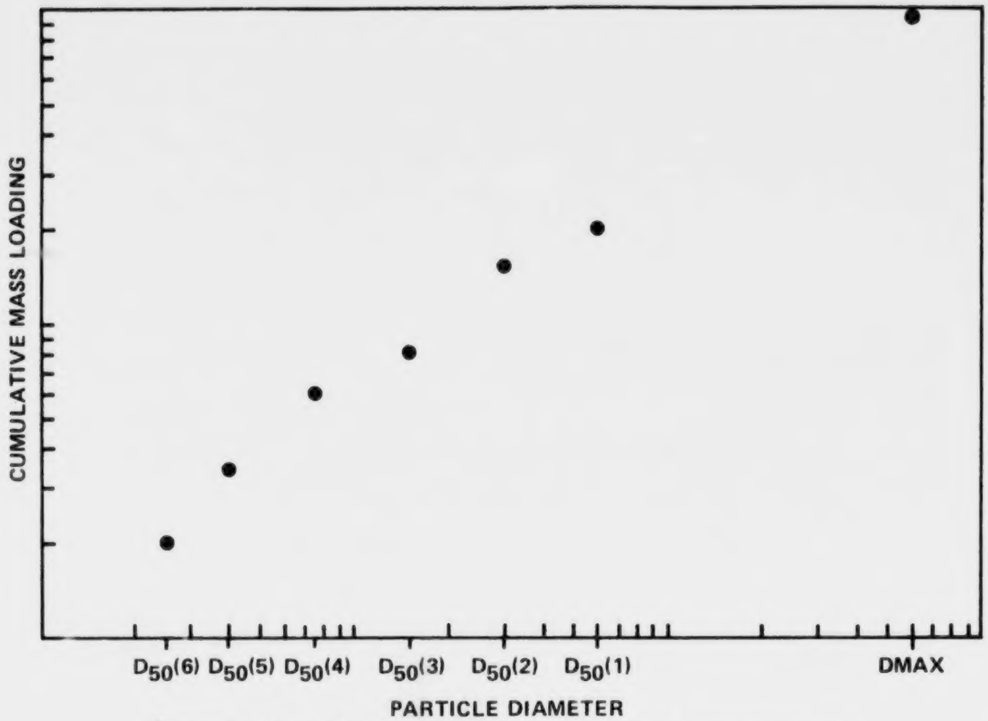

Figure 1a. Cumulative size distribution from raw impactor data.

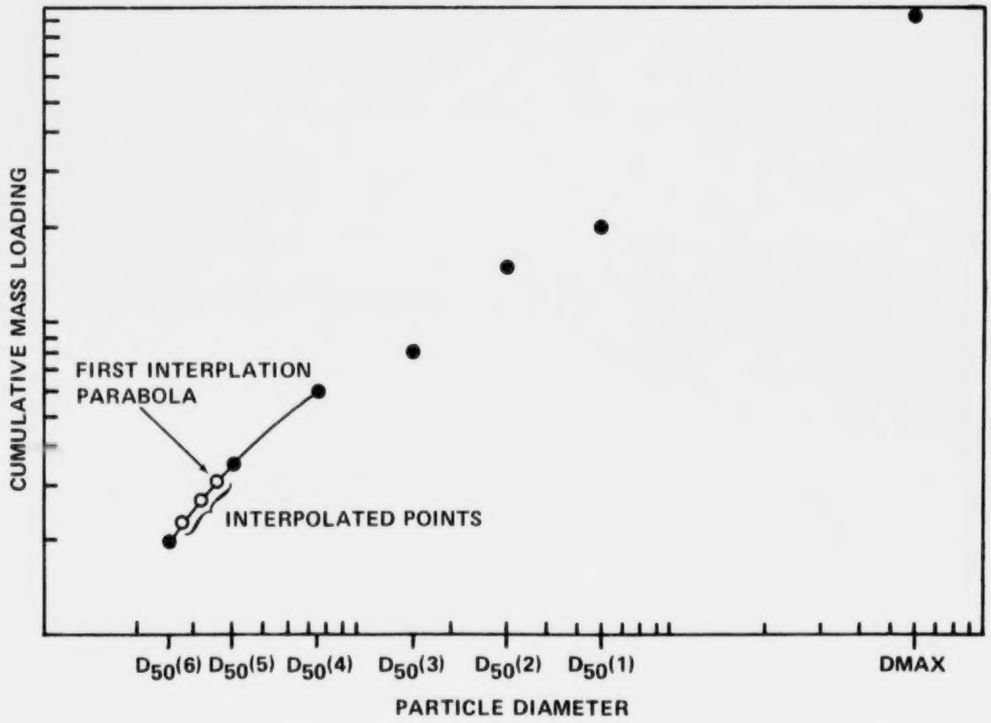

Figure 1b. Start of development of interpolated points between first and last D_{50}.

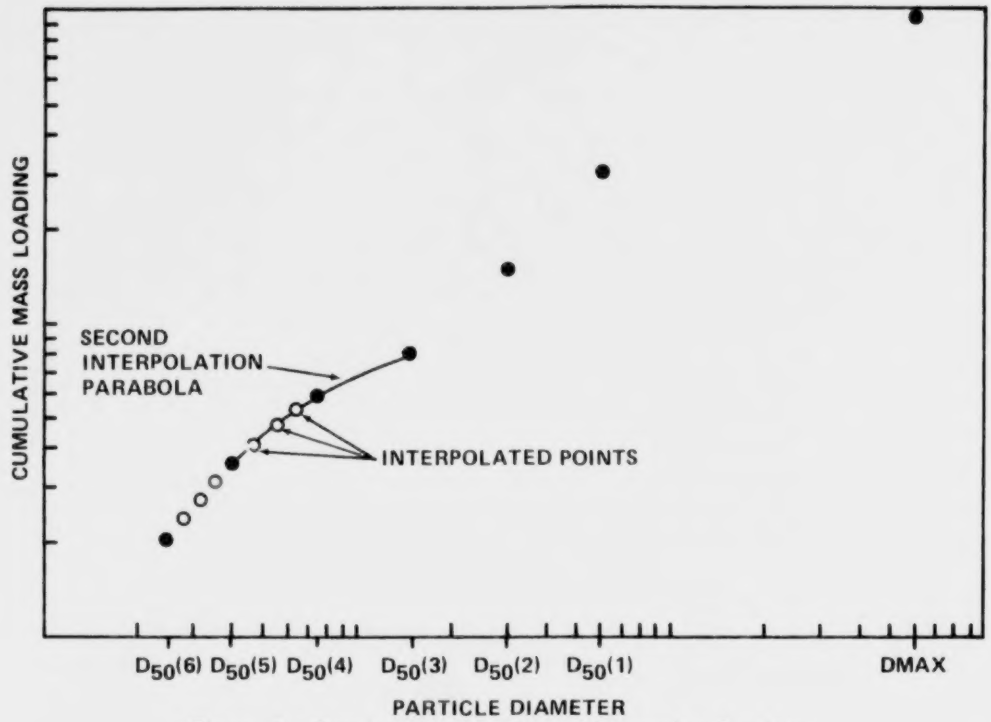

Figure 1c. Continued generation of interpolated points

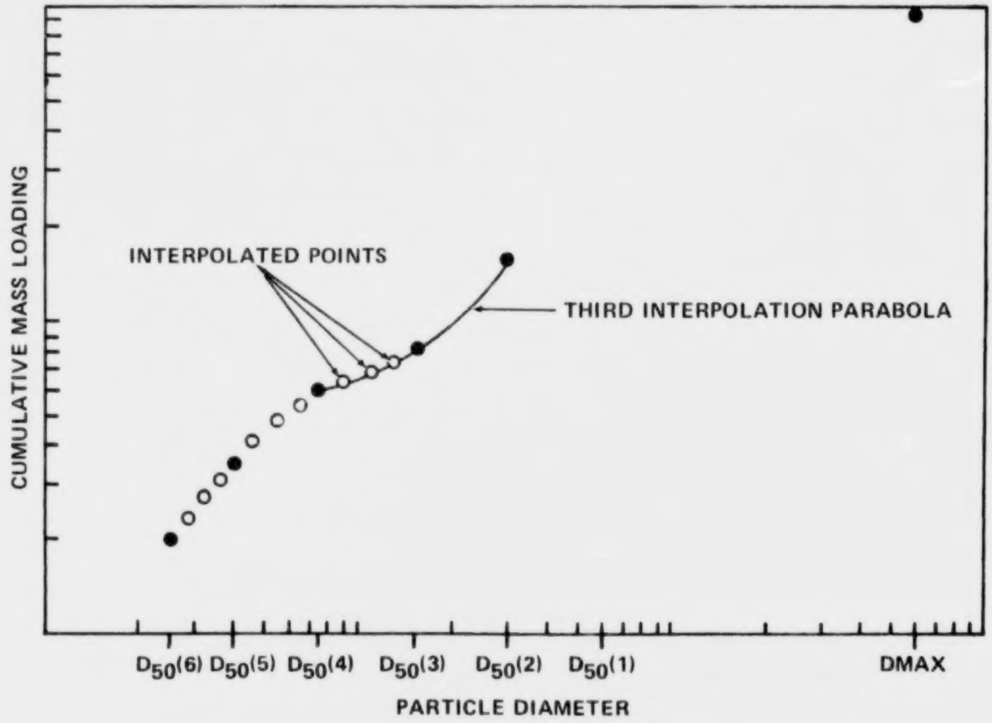

Figure 1d. Continued generation of interpolated points

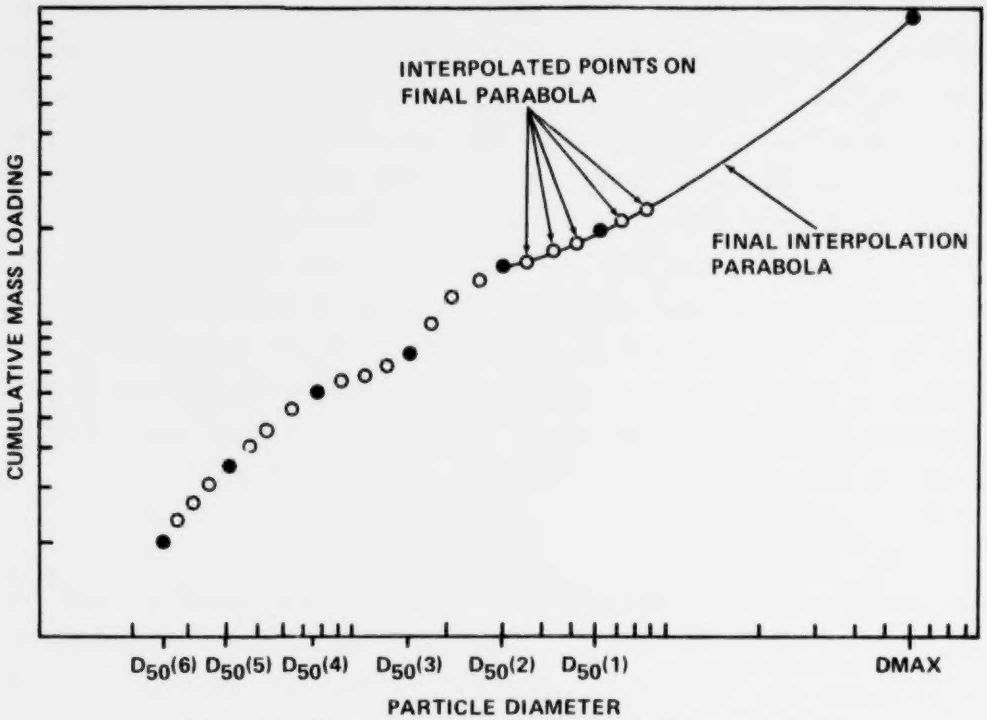

Figure 1e. Generation of interpolated points on parabola which includes DMAX.

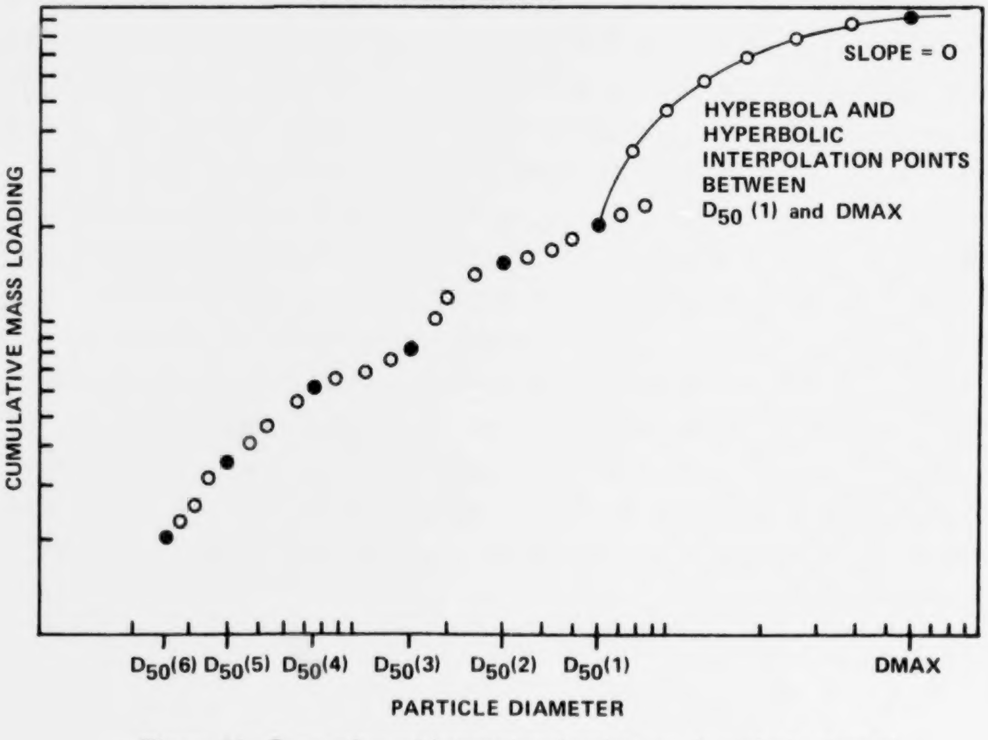

Figure 1f. Generation of interpolated points on hyperbola through $D_{50}(1)$ and DMAX

In the region about the first stage D_{50}, three sets of interpolated points are generated. The first are generated by parabolic interpolation using a parabola through DMAX, D_{50} (stage 1), and D_{50} (stage 2) as was done in the case of the previous segments. However, in addition to these, three more points are generated along the parabola above the first stage D_{50}. These additional points are spaced evenly in log (diameter) at the same intervals in log (diameter) as the interpolated points between D_{50} (stage 1) and D_{50} (stage 2) as shown in Figure 1e. These points are used in generating the final curve fit up to the point on the cumulative distribution curve defined by the first stage D_{50}. The third set of points is illustrated in Figure 1f.

Note that the cumulative mass distribution used in the illustrations of Figure 1 is one in which a large step in concentration occurs between D_{50} (stage 1) and DMAX. This is typical of a cumulative curve for a bimodal distribution in which one mode has a median diameter substantially greater than first stage D_{50}. The interpolation parabola through DMAX, D_{50} (stage 1) and D_{50} (stage 2) does not properly represent the shape of the true distribution curve in this region. In particular, the true curve must have zero slope at DMAX. It was empirically determined that a hyperbolic interpolation equation fit in terms of linear concentration and linear diameter between DMAX and D_{50} (stage 1) with the hyperbola asymptotic to the total loading at infinite particle size resulted in very acceptable results in the final spline fits. Therefore a seven point hyperbolic interpolation is used in addition to the previously described parabolic interpolation over this segment of the curve. This hyperbolic interpolation is illustrated in Figure 1f. The use of the two sets of interpolated points in the final interval will be discussed later.

Generation of the Final Spline Fit--

The original data points, together with the interpolated points just generated, form a set of points along a continuous curve (if one disregards the two sets of points in the final segment) which has no negative slopes. However, the derivative of the curve in most cases will not be continuous at the D_{50} points. The spline fit to be described is a smoothing technique which generates a series of parabolic segments that approximates a continuous curve through the complete set of points defining the cumulative distribution. The segments to be generated now will pass near or through those points and will have forced continuity in both coordinates and first derivatives. The technique is applied first to cover the interval between the first and last D_{50}'s and then a second time to cover the interval between the first stage D_{50} and DMAX. From this point on, no distinction is made between the original points defined by the D_{50}'s and the interpolated values located between them.

The spline fit is generated by joining successive parabolas at points located by the x (or log diameter) coordinates of the points which now represent the cumulative distribution curve (original points at the D_{50}'s plus the interpolated points). These parabolas have continuity in slope forced by the fitting procedure and are generated in such a fashion as to pass near or through the points on the cumulative distribution curve.

The procedure is illustrated in Figures 2. The spline fit is begun at the lowest point on the distribution curve (at the D_{50} of the last stage). The parabola used to generate the interpolated points between the last two stages is assumed to be the fitted curve up to the first interpolated point. (Point 1 in Figure 2a.) This parabola, a, is followed until the x-coordinate at point 1 is reached. At the point A, located on this parabola by the x-coordinate of point 1, a new parabola is fitted as shown in Figure 2b. This parabola, b, is forced to pass

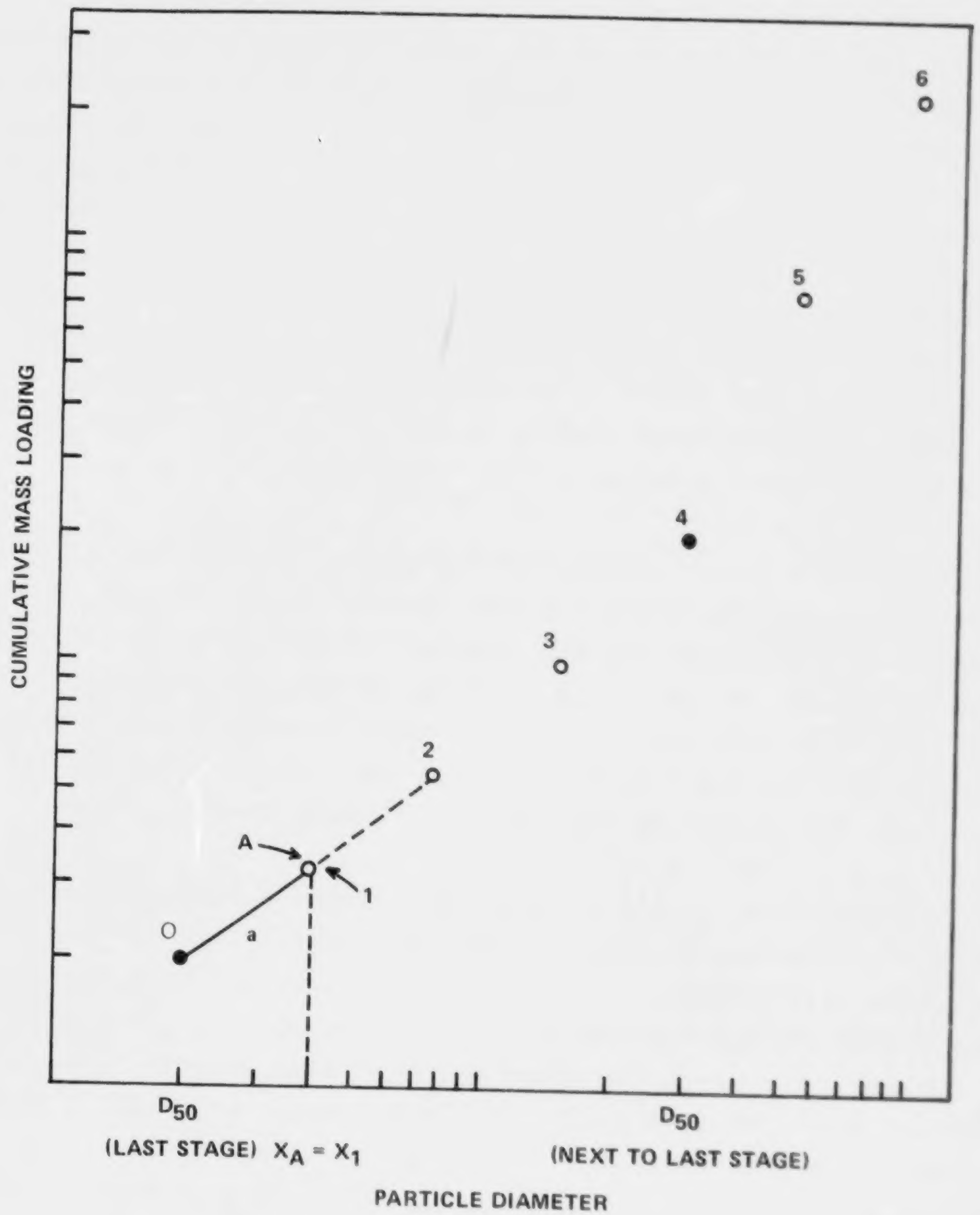

Figure 2a. *Start of the curve fitting procedure. Cumulative mass loadings derived from stage catches are represented by solid circles. Interpolated values are shown with open circles.*

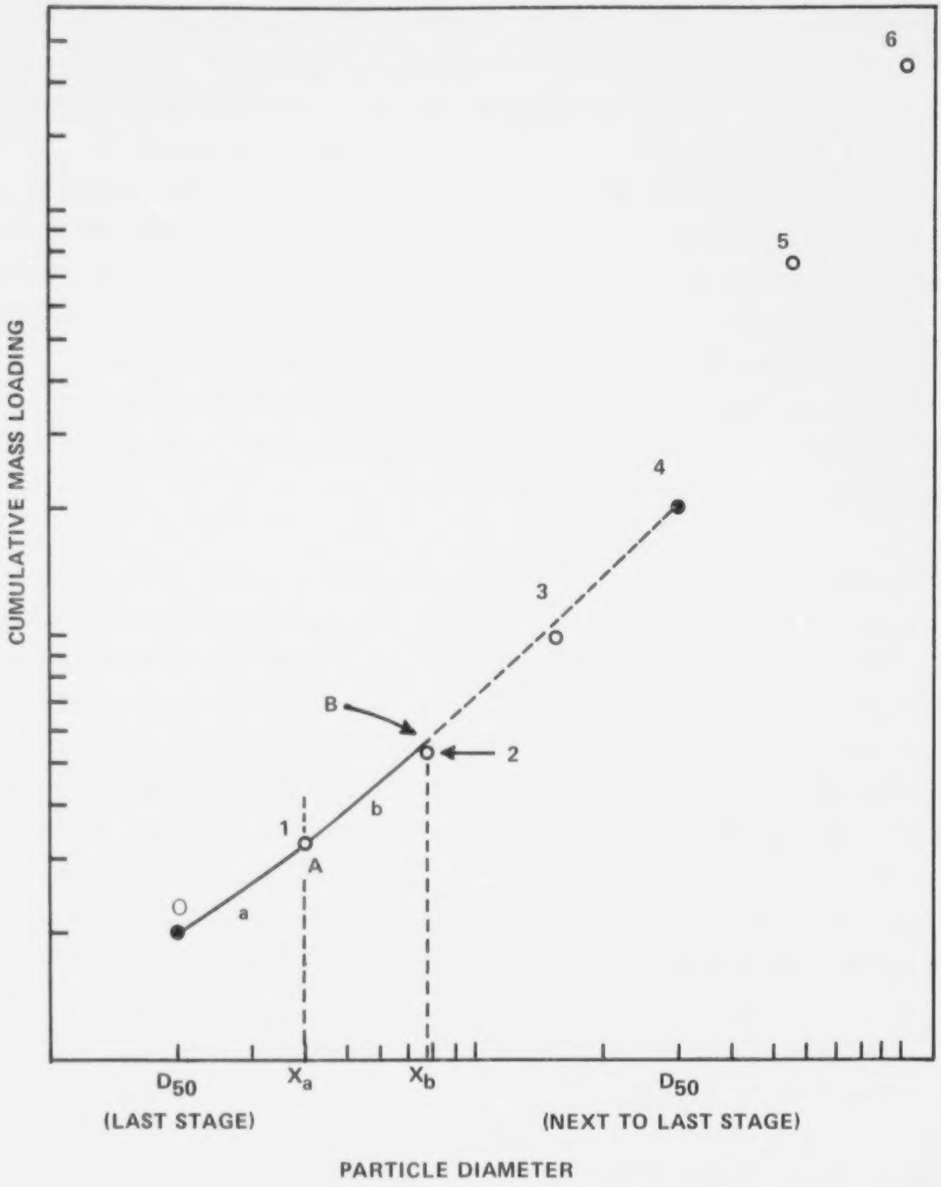

Figure 2b. *Second step in the curve fitting procedure. Cumulative mass loadings derived from stage catches are represented by solid circles. Interpolated values are shown with open circles.*

through point A with the same slope at A as the parabola used to define point A, and is forced to pass through the third point above point 1 in the set of points defining the cumulative curve, i.e., point 4. The parabola, b, is followed to the point defined by the x-coordinate of point 2, thus locating a point B. At B a new parabola is fit with forced slope continuity with b passing through the third point ahead of point 2, i.e., point 5, as shown in Figure 2c. From C this process is repeated using point C and 6 to generate a new parabola, d, and termination point D, e, and E, etc., until a termination point at the D_{50} of the first collection stage is reached. The last three points obtained by parabolic interpolation are used in generating the spline fit parabolas up to the first collection stage D_{50}. The coefficients of the fitting spline fit parabolas for the segments a, b, c, d, ... etc., are saved for future use. These now represent the smoothed curve and will be used henceforth to define the cumulative curve for that run.

The final spline fit starts by picking up at the point on the fitting parabola which terminated at the D_{50} of the first stage. The same procedure as before is followed, except that the third point ahead determined by the hyperbolic interpolation is now used for fitting, and the fitting parabolas are followed to x-coordinates defined by the hyperbolic interpolation points. The curve generated in this second zone of the spline fit (i.e., between D_{50} (stage 1) and DMAX) is an extrapolation, but one which has been found to be quite good to diameters equal to about 2 to 3 times the first stage D_{50} for unimodal distributions.

The cumulative concentration and slope of the cumulative curve, dm/d log D, can be calculated for any arbitrary particle size by locating the fitting coefficients for the spline segment containing that size. The boundary locations of each of the parabolic segments, O, A, B, C, ..., and the fitting coefficients for each segment are stored in a disk file for subsequent use by other programs (e.g., GRAPH, STATIS, etc.).

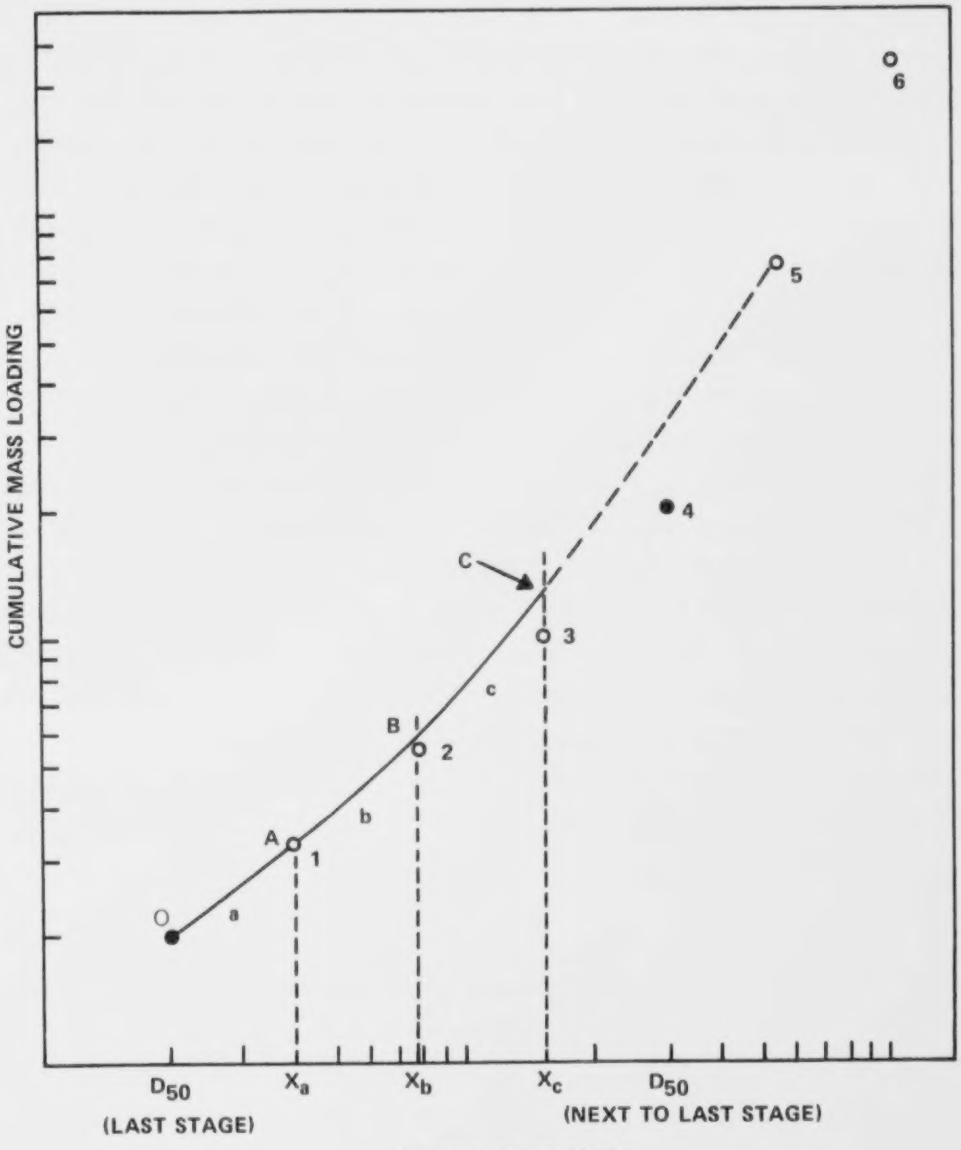

Figure 2c. *Third step in the curve fitting procedure. Cumulative mass loadings derived from stage catches are represented by solid circles. Interpolated values are shown with open circles.*

Problems Resulting from Extremely Close Stage Cut Diameters (D_{50}'s)--

In the case of certain impactors (Andersen, University of Washington, and MRI), calibration data indicate that the first two stages have effective D_{50}'s which are very nearly equal. When two stages are used which differ only slightly in D_{50}, the second of the two will collect too much material because of the finite slope of real impactor stage collection characteristics. The simplest example of this effect would be obtained if two identical stages are used sequentially. If that were the case, in an ideal impactor the second stage should collect no material; however, because of the finite slope of the real stage collection efficiency curve, it will. This could lead to the formation of a step increase (infinite slope) in the cumulative concentration curve. The severity of the effect is reduced as the spacing between the D_{50}'s increases but can be sufficiently severe so as to cause significant errors in the size distribution curves if it is not properly accounted for. The program MPPROG, because of this problem, ignores the presence of the second stage of Andersen, MRI, and University of Washington impactors in generating the cumulative mass concentration data from which the fitted curves will be made by SPLIN1. This procedure effectively nullifies the problem. However, if calibrations of future versions of these impactors do not show the small spacing in D_{50}, MPPROG should be modified appropriately so as not to lose good information when the curve fits are made.

GRAPH

Program GRAPH is dedicated entirely to presenting data from single impactor runs. The output forms available on call are cumulative mass loading versus D_{50} and $\Delta M/\Delta \log D$ versus geometric mean diameter as calculated in MPPROG. The latter are available on both Stokes, aerodynamic and aerodynamic impaction diameter bases. As an option, up to ten runs can be superimposed on a single plot. Plots and tabular output of the fitted curves from SPLIN1 are also available. The fitted curves from SPLIN1 are plotted superimposed on the data points from MPPROG, but only as single run plots. The plots are all made on log-log grids.

The tabular output includes only dM/dlogD versus particle diameter generated by differentiation of the SPLIN1 fitted curves.

ANALYSIS OF GROUPED DATA

STATIS

STATIS is a program for combining data from multiple impactor runs under a common condition. The program tests data from a series of runs specified by the user for outliers, flags and removes outliers from the set, and then provides output in the form of averaged size distributions with 50% confidence intervals as desired in both tabular and graphical form. The program is set up to provide 50% confidence intervals; however, changes can be made for the calculation of 90% confidence intervals. These changes are documented in the explanation of STATIS.

The input data to STATIS are the fitted polynomial segments generated from MPPROG by SPLIN1 which now define the cumulative mass loadings for each run. The individual runs to be included in the averages and the particle diameter basis (i.e., aerodynamic, aerodynamic impaction, Stokes) are user specified on control cards used to execute STATIS.

The fitting equations from SPLIN1 are differentiated at preselected particle diameters to obtain the quantity $(dM/dlogD_i)_j$ where i refers to particle diameter and j refers to the sequence number of a particular run in the set to be averaged. The values, at each particle diameter, D_i, are subjected to an outlier analysis based on the deviations of the values of dM/d log D for individual runs from the mean for all runs.

The outlier test used is that for the "Upper 5% Significance Level" as given in Quality Assurance Handbook for Air Pollution Measurement Systems, Vol. 1. Principles. (EPA-600/9-76-005, January 1976, Section No. F, pp. 5-9). A curve fitted to the tabular list at critical values for excluding an outlier is used to generate the table. A tested value X_i is an outlier if

$$\frac{|X_i - \bar{X}|}{S} > C_n \qquad (22)$$

C_n = critical value = function of the number of points in the data set
X_i = individual value

$\bar{X}$ = mean of all values
S = standard deviation at the data set.

The application of this test requires that there be three or more runs in the sequence to be averaged. This outlier test is repeated after discarding any outliers already identified, provided there are at least three runs remaining in the set of retained points.

After discarding outliers for each $(dM/dlogD)_i$, a final average, standard deviation, and 50% confidence interval are calculated. These values are output on the line printer and are plotted on demand by the user.

Cumulative size distributions on a mass basis or percentage basis are derived from the averaged dM/dlogD values by integration of these values. The choice of integrating the dM/dlogD curve rather than direct computation of the cumulative averages from the individual cumulative distributions was based on the fact that an error in a single stage weight is propagated forward throughout the cumulative curve for all stages subsequent to the one on which the error occurred. This would cause substantial quantities of good data from other stages to be discarded by the outlier analysis. Integration of the averaged differential distribution, on the other hand, allows the data from the remaining, error free, stages to have their proper influence on the averaged cumulative distributions. These cumulative distributions are again output in tabular form and, on call, in graphical form.

The cumulative distributions can be obtained either including or excluding particles smaller than 0.25 μm in diameter. The option of excluding the particles smaller than 0.25 μm results from the fact that in a significant percentage of sampling situations, impactor back up filter catches can be dominated by oversize particles because of bounce and/or reentrainment. This results in a filter weight gain which can be many times higher than the weight of the fine particles which, ideally, should be the only material present. In those cases, omission of the material which is nominally smaller than 0.25 μm from the cumulative distributions will make the result a much better representation of the true size distribution.

Standard deviations and confidence limits for the cumulative distributions are calculated from the approximation that the variance (and square of a confidence interval) for a sum, A + B, is given by the sums of the variances (and squares of the confidence intervals) for A and B separately, *i.e.*,

$$\text{Variance}_{A+B} = \text{Variance}_A + \text{Variance}_B \tag{23}$$

and

$$(\text{confidence interval})^2_{A+B} = (\text{confidence interval})^2_A + (\text{confidence interval})^2_B \tag{24}$$

The averaged differential size distributions generated by STATIS are stored in a disc file for use by the programs PENTRA or PENLOG in calculating control device fractional efficiency curves.

Tabular and graphical output from STATIS includes cumulative mass loading versus diameter, cumulative percentage on a mass base versus diameter, dM/dlogD versus diameter, and dN/dlogD versus diameter. The graphical presentations are made on log-log grids with the exception of the cumulative percentage plot which is made on a log-probability grid. All output forms, graphical and tabular, include confidence limits. The choice of diameter definition used is left to the user. An index of runs which were rejected through the outlier analysis before averaging is also printed. Rejection at any one particle size does not result in the run being excluded at all particle sizes.

Programs PENTRA/PENLOG

These two programs are virtually identical and provide tabular and graphical output of control device penetration and/or efficiency versus particle size for a preselected series of particle sizes from about 0.25 to 20 μm. The only difference between the two programs is in the form of the graphical output. In the case of PENTRA, the fractional efficiency curves are presented on a log-probability grid while in PENLOG they are presented on a log-log grid.

The calculations are made from averaged sets of inlet and outlet data developed by STATIS. The user identifies the pair of averaged data sets from which the efficiency is to be calculated together with the diameter basis required (*i.e.*, Stokes, aerodynamic, aerodynamic impaction). The program retrieves the appropriate averaged data sets and calculates the fractional efficiency as

$$\text{efficiency}_i(\%) = \left[1 - \frac{(dm/d\log D_i)_{outlet}}{(dM/D\log D_i)_{inlet}}\right] \times 100 \qquad (25)$$

where i refers to the i^{th} particle diameter in the preselected diameter sequence. Simultaneously, if both the inlet and outlet data sets included two or more runs, confidence limits are calculated based on a method described by Y. Beers.[6] The confidence level associated with the limits generated by the program are 50% levels in the program as provided; however, other levels can be generated by simply changing values of three constants used to generate the appropriate t-table.

SECTION 3

PROGRAMMING DETAILS

This section provides detailed breakdowns on the programs and subprograms used in CIDRS. The description of the programs given here are keyed to the line sequence numbers of the program listings which make up Section 5 of this manual.

PROGRAM MPPROG

The purpose of program MPPROG is to calculate all of the necessary variables (viscosity, mean free path, slip correction factor, etc.) in order to obtain stage D_{50}'s or cut point diameters, cumulative mass loadings, and differential size distributions on both a mass and number basis for cascade impactors. The program handles data collected by the Andersen Mark III Stack Sampler, the modified Brink Cascade Impactor, the University of Washington Mark III Source Test Cascade Impactor, or the Meteorology Research Incorporated Cascade Impactor. This is the first of a series of four programs which together yield a complete profile of a particulate loading at the tested point. This may be either at the inlet or outlet of the gas cleaning device. A fifth program compares inlet and outlet testing to yield the devices penetration-efficiency.

All input for MPPROG is received by card reader. The cut point diameters, cumulative mass loadings, and a preliminary view of the differential size distributions are output on a line printer. Much of this information is also output on a disk file. This file serves as input data for later programs in the series.

Breakdown of Program MPPROG

032-112: Read input data from cards.

Set the value of NMASS which is the number of masses to be read:

NMASS = 9 if using the Andersen Mark III Stack Sampler
= 9 if using the modified Brink Cascade Impactor
= 8 if using the University of Washington Mark III Source Test Cascade Impactor
= 8 if using the Meteorology Research Incorporated Cascade Impactor

Set the value of NCUM which is the number of cumulative mass loadings less than stage D_{50}:

NCUM = 8 if using the Andersen Impactor
= 7 if using the Brink Impactor, the University of Washington Impactor, or the MRI Impactor

The only calculation here is a conversion of the units of mass on each stage (including the filter) to grams using the mass on each stage in milligrams as input.

$$MASS_I = MASS_I /1000.0, \quad I = 1,9$$

The order here is from mass on the back-up filter (I=1) to mass on the first stage (I = NMASS=8 or 9) or cyclone (if used).

113-116: Increment the index NRUN for each set of data read in here.

117-125: If D_{50}'s, cumulative mass loadings, etc., are desired using both the classic definition and Mercer's definition of aerodynamic diameter, the input density RHO will be 1.0 (rather than a physical density). In this case, the index which signals the definition of aerodynamic diameter to be used, NAERO, is set equal to 0 so that D_{50}'s, cumulative mass loadings, etc., are calculated based on the TGLD definition for the first computation. (D_{50}'s, mass loadings, etc., are calculated based on Mercer's definition of aerodynamic diameter for the second computation.)

126-131: Calculate the wet fractional gas composition, FG_I, I = 1,4, for carbon dioxide (I=1), carbon monoxide (I=2), nitrogen (I=3), and oxygen (I=4) using the input dry fractional gas compositions, FG_I, I = 1,4 in the formula:

$$FG_I = FG_I \, (1.0 - FG_5), \text{ where} \qquad (26)$$

FG_5 is the fractional water content.

132-135: Define the average molecular weight of air to be RA = 28.97 atomic mass units.

136-139: Calculate the average molecular weight of the flue gas in atomic mass units, MM, using the wet gas composition fractions, FG_I, I = 1,5, (for carbon dioxide, carbon monoxide, nitrogen, oxygen, and water, respectively) by the formula:

$$MM = (44.10\ FG_1)+(28.01\ FG_2)+(28.02\ FG_3)+(32.00\ FG_4) + (18.02\ FG_5) \qquad (27)$$

140-143: Calculate the temperature of the gas in the impactor in degrees centigrade, TCI, using the input temperature of the gas in the impactor in degrees Fahrenheit, TFI, by the formula:

$$TCI = (5/9)\ (TFI-32.0) \qquad (28)$$

144-147: Calculate the temperature of the gas in the impactor in degrees Kelvin, TKI, using the input temperature of gas in the impactor in degrees Fahrenheit, TFI, by the formula:

$$TKI = 273.0 + [(5/9)\ (TFI-32.0)] \qquad (29)$$

148-151: Calculate the temperature of the gas in the impactor in degrees Rankine, TRI, using the input temperature of gas in the impactor in degrees Fahrenheit, TFI, by the formula:

$$TRI = TFI + 460.0$$

152-155: Calculate the temperature of gas in the stack in degrees centigrade, TCS, using the input temperature of gas in the stack in degrees Fahrenheit, TFS, by the formula:

$$TCS = (5/9)\ (TFS-32.0)$$

156-159: Calculate the temperature of gas in the stack in degrees Kelvin, TKS, using the input temperature of gas in the stack in degrees Fahrenheit, TFS, by the formula:

$$TKS = 273.0 + [(5/9)\ (TFS-32.0)]$$

160-163: Calculate the gas flow rate for impactor conditions in actual cubic feet per minute, Q, using the input gas flow rate for stack conditions in actual cubic feet per minute, F, the temperature of gas in the impactor in degrees Kelvin, TKI, and the temperature of gas in the stack in degrees Kelvin, TKS:

$$Q = F(TKI/TKS)$$

164-167: Calculate the gas pressure at the impactor inlet in atmospheres, POA, using the input gas pressure at the impactor inlet in inches of mercury, PO:

$$POA = PO/29.92$$

168-175: Calculate the drop in pressure across the impactor in inches of mercury, DP. From the ideal gas law:

$$PV = NkT$$

where P = pressure, inches of mercury

V = volume, cubic meters

N = total number of molecules in volume V

k = Boltzmann's constant

T = temperature, degrees Kelvin

and the ideal orifice equation (Eq. 12), the following relationship is easity derived:

$$\Delta P = (DPCON_J)\ (Q^2 PO/TRI)\ (MM) \qquad (35)$$

where $DPCON_J$ = a constant determined imperically for each impactor type

Q = gas flow rate for impactor conditions, actual cubic feet per minute

PO = gas pressure at impactor inlet, inches of mercury

TRI = temperature of gas in the impactor, degrees Rankine

MM = average molecular weight of the flue gas, atomic mass units.

The values of $DPCON_J$ for each impactor (given in the data statement at card 029) as empirically determined are:

J	$DPCON_J$	Impactor
1	1.287	Andersen
2	3.783×10^2	Brink (last stage = stage 5)
3	3.928	Univ. of Washington
4	1.093×10^3	Brink (last stage = stage 6)
5	9.375	MRI

176-179: Calculate the drop in pressure across the impactor in atmospheres, DPA, using the drop in pressure across the impactor in inches of mercury, DP:

$$DPA = DP/29.92 \qquad (36)$$

180-183: Call subroutine STAGE to calculate the local pressure at each impactor stage in atmospheres, PS_I, I = 1, NCUM.

184-187: Call subroutine VIS to calculate the gas viscosity in poise, MU.

188-191: Call subroutine MEAN to calculate the molecular mean free path at each impactor stage in centimeters, L_I, I = 1, NCUM.

192: RHO1 is the input particle density. The initial value is the aerodynamic density, 1.0 gram per cubic centimeter. Note that density is read in as RHO, but this value is saved as RHO1, if RHO is input as physical density. If RHO is input as aerodynamic density, both RHO and RHO1 are 1.0 gram per cubic centimeter.

193-196: The program comes to this continue statement 2010 (card 193) twice for each input set of data. The first calculations are made for assumed physical density if density is input as a value greater than 1.0 gram per cubic centimeter. The first calculations are made for assumed unit density using the classic definition of aerodynamic diameter as defined by the Task Group on Lung Dynamics (TGLD)[1] if density is input as 1.0 gram per cubic centimeter. (In this second case, NAERO= MAERO is overridden. It is set equal to 1 to get second calculations for D_{50}, cumulative mass loadings, etc., based on Mercer's definition[2] of aerodynamic density.) The record number, IS, of file KMC001 (file 10) is odd where the D_{50} values, cumulative mass loadings, etc., are stored for these first calculations. Each time the program passes this continue statement 2010, the record number, IS, is incremented by one. Thus, on the second traverse for a given set of data, IS is even. Here the assumed density, RHO, is unit density = 1.0 gram per cubic centimeter. The definition of aerodynamic density used for these second calculations is dependent on the input code value MAERO. If calculations for the TGLD aerodynamic diameter have been made on the first traverse (RHO input as 1.0), NAERO is set equal to 1 and this second traverse yields D_{50}'s cumulative mass loadings based on Mercer's definition. If calculations for physical density have been made on the first traverse, these aerodynamic values may be calculated according to the TGLD (MAERO input as 0) or Mercer's definition (MAERO input as 1). Also, the input maximum particle diameter in micrometers, DMAX, is modified for assumed aerodynamic diameter

$$\text{DMAX} = (\text{RHO1})^{\frac{1}{2}}\ \text{DMAX}$$

where RHO1 is the input density in grams per cubic centimeter.

197-200: Call subroutine CUT to calculate the lower size limit of D_{50} of each stage in micrometers, DPC_I, I = 1,NCUM, where NCUM = 8 for the Andersen impactor or NCUM = 7 for the Brink, University of Washington, or MRI impactor. Also, this subroutine calculates the cut point of the cyclone in micrometers, CYC3, if the Brink impactor is used.

201-205: Call subroutine CUM to calculate the cumulative mass distribution in grams, CUMM_I, I = 1,NMASS, and the cumulative percent mass distribution value, PERCU_I, I = 1,NMASS. NMASS = 9 for the Andersen or Brink impactor or NMASS = 8 for the University of Washington or MRI impactor. These distributions are ordered such that the least cumulative mass value is CUMM1. It represents the mass on the filter only; CUMM2 is the sum of the masses on both the filter and the last stage; $\text{CUMM}_{\text{NMASS}}$ is the sum of all masses through the first or coarsest stage (or the cyclone if applicable). The cumulative percent mass distribution, PERCU, is ordered in the same manner. This subroutine also finds the total mass loading in grains per actual cubic foot, GRNA, in grains per normal dry cubic foot, GRNS, in milligrams per actual cubic meter, GRNAM, and in milligrams per normal dry cubic meter, GRNSM.

206-211: This loop changes the fractional flue gas composition, FG_I, I = 1,5, to percent flue gas composition

$$FG_I = FG_I \times 100.0,\ I = 1,5 \qquad (37)$$

(Recall that these percentages represent CO_2, CO, N_2, O_2, and H_2O, respectively.)

212-222: Define new variables for the mass captured on each stage in grams, $IMASS_I$, I = 1,NMASS, which are the same as $MASS_I$, I = 1,NMASS, except that the ordering is reversed. For example:

$$\begin{aligned} IMASS_1 &= MASS_{NMASS} \\ &\vdots \\ IMASS_6 &= MASS_{(NMASS + 1 - 6)} \\ &\vdots \\ IMASS_{NMASS} &= MASS_1 \end{aligned}$$

Likewise define new variables for cumulative mass captured at each stage, $ICUMM_I$, I = NMASS, and new variables for cumulative percent mass captured at each stage, $PRCU_I$, I = 1,NMASS. These are the same as $CUMM_I$, I = 1,NMASS and $PRCU_I$, I = 1,NMASS, respectively, except that the ordering has been reversed. For example:

$$\begin{aligned} ICUMM_1 &= CUMM_{NMASS} \\ &\vdots \\ ICUMM_6 &= CUMM_{(NMASS + 1 - 6)} \\ &\vdots \\ ICUMM_{NMASS} &= CUMM_1 \end{aligned}$$

and

$$\begin{aligned} PRCU_1 &= PERCU_{NMASS} \\ &\vdots \\ PRCU_6 &= PERCU_{(NMASS + 1 - 6)} \\ &\vdots \\ PRCU_{NMASS} &= PERCU_1 \end{aligned}$$

NMASS is the number of stage catches. NMASS = 9 for the Andersen or Brink impactor; NMASS = 8 for the University of Washington or MRI impactor.

223-229: This loop converts the mass collected on each stage in grams, $IMASS_I$, I = 1,NMASS, and the cumulative mass at each stage in grams, $ICUMM_I$, I = 1,NMASS, to milligrams:

$$IMASS_I = IMASS_I \times 1000.0, \quad I = 1,NMASS \tag{38}$$

$$ICUMM_I = ICUMM_I \times 1000.0, \quad I = 1,NMASS \tag{39}$$

Again, NMASS is the number of stage catches. NMASS = 9 for the Andersen or Brink impactor; NMASS = 8 for the University of Washington or MRI impactor.

230-249: For each stage:

Calculate the mass loading of particulate with diameters less than the D_{50} of the given stage in milligrams per actual cubic foot, $CUMG_I$, I = 1,MLS, using the total loading in milligrams per actual cubic meter, GRNAM, and the cumulative percent of total mass up to and including the stage having the next smaller D_{50}, $PRCU_{I + MMM}$, I = 1,MLS

$$CUMG_I = GRNAM\ (PRCU_{I + MMM}/100.0) \tag{40}$$

Calculate the mass loading for particulate diameters less than the D_{50} of the given stage in grains per dry normal cubic foot, CUMM(I), I = 1,MLS, using the total loading in grains per actual cubic foot, GRNA, and $PRCU_{I + MMM}$, as described above:

$$CUMH_I = GRNA\ (PRCU_{I + MMM}/100.0) \qquad (41)$$

Calculate the mass loading of particulate with diameters less than the D_{50} of the given stage in grains per day normal cubic foot, $CUMI_I$, I = 1,MLS, using the total loading in grains per dry normal cubic foot, GRNS, and $PRCU_{I + MMM}$ as described above:

$$CUMI_I = GRNS\ (PRCU_{I + MMM}/100.0) \qquad (42)$$

Calculate the mass loading of particulate with diameters less than the D_{50} of the given stage in milligrams per dry normal cubic meter, $CUMJ_I$, I = 1,MLS, using the total loading in milligrams per dry normal cubic meter, GRNSM, and $PRCU_{I + MMM}$ as described above:

$$CUMJ_I = GRNSM\ (PRCU_{I + MMM}/100.0) \qquad (43)$$

The total number of cumulative mass loadings less than stage D_{50},MLS, and the value added to the PRCU index, MMM, are dependent on the impactor used and its configuration. For the Andersen, the University of Washington, or the MRI impactor, the number of cumulative mass loading values, MLS, is the same as the number of stages (excluding the filter), NCUM. NCUM = 8 for the Andersen impactor; NCUM = 7 for the University of Washington or the MRI impactor. Also, in these three cases, the cumulative percent mass used to find the mass loading of a given stage is the cumulative percent mass up to the next stage. Therefore, MMM = 1. For the Brink impactor the values of MLS and MMM are dependent on the impactor configuration used:

$$MLS = MC3 + MOO + 6 \qquad (44)$$

$$MMM = 3 - (MC3 + MOO) \qquad (45)$$

Recall that MC3 is the code variable for use of the cyclone. It is 1, when the cyclone is used; 0, when not used. Likewise, M00 is the code variable for use of stage 0.

250-257: Calculate the mass loading in milligrams per dry normal cubic meter, $GGRNS_I$, I = 1,NMASS, using the mass collected on the given stage in grams, $IMASS_I$, I = 1,NMASS, the temperature of the stack in degrees Kelvin, TKS, the flow rate under stack conditions in actual cubic feet per minute, F, the sampling duration in minutes, DUR; the pressure at the impactor inlet in atmospheres, POA, and the percent water content of the gas, FG_5, by the formula:

$$GGRNS_I = \frac{IMASS_I \; 15.4324 \; TKS \; 2288.34}{F \; DUR \; 294.0 \; [1.0-FG_5/100.0)] \; POA \; 1000.0} \qquad (46)$$

where I = 1,NMASS.

258-274: Regardless of the impactor used, this section outputs the following information by line printer:

ID - general identification label
F - impactor flow rate under stack conditions in actual cubic feet per minute
TFI - impactor temperature in degrees Fahrenheit
TCI - impactor temperature in degrees centigrade
DUR - sampling duration in minutes
DP - drop in pressure across the impactor in inches of mercury
TFS - stack temperature in degrees Fahrenheit
TCS - stack temperature in degrees centigrade
RHO - assumed density (physical or unit) in grams per cubic centimeter

PO - gas pressure at impactor inlet in inches of mercury

DMAX - maximum particle diameter in micrometers

FG_{1-5} - wet percent flue gas composition (CO_2, CO, N_2, O_2, and H_2O, respectively)

GRNA - total mass loading in grains per actual cubic foot

GRNAM - total mass loading in milligrams per actual cubic meter

GRNSM - total mass loading in milligrams per normal dry cubic meter

275-535: This large section outputs the following information on the line printer:

Impactor Stage - column headings showing the stage name as imprinted on the metal

Stage Index Number - column headings corresponding to the "Impactor Stage" as above, but numbered 1 to NMASS where NMASS is the number of captured masses

CYC3,DPC - if the Brink impactor is used with the cyclone, its lower size limit in micrometers, CYC3, is printed; the lower size limits of the stages, DPC, are (then) listed

IMASS - masses captured on each stage and on the filter, (and in the cyclone, if applicable) in milligrams

GGRNS - the mass loading per stage and at the filter (and cyclone, if applicable) in milligrams per normal dry cubic meter

PRCU - percent of total mass on each stage and on the filter (and in the cyclone, if applicable)

CUMG - cumulative mass loading less than each stage D_{50} in milligrams per actual cubic meter

CUMJ - as above in milligrams per dry normal cubic meter

CUMH - as above in grains per actual cubic foot

CUMI - as above in grains per dry normal cubic foot

The format that is used to print out the information listed above depends on the type of impactor. If the Brink impactor is used, the format also depends on its configuration (cyclone, number of stages, etc.).

Andersen - begins at statement 3001; uses cards 281-304

Brink - begins at statement 3100; cards used are dependent on configuration:

Configuration	Cards
cyc.,stage 0,...,stage 5 or 6	312-377
stage 0,stage 1,..,stage 5 or 6	379-445
stage 1,stage 2,..,stage 5 or 6	446-511

Univ. of Wash. or MRI -begins at statement 3200: uses cards 512-535.

536-539: Call subroutine DMDNGD to calculate and print out the values of the geometric mean diameter at each stage in micrometers, GEOMD, the values of mass size concentration at each of these mean sizes in milligrams per normal dry cubic meter, DMDLD, and the value of number size concentration at each of these mean sizes in number of particles per normal dry cubic meter, DNDLD.

540-543: Write a footnote defining normal or engineering standard conditions - "NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C and 760 MM HG."

544-553: If calculations have been made here for assumed aerodynamic diameter, a footnote is also written here indicating the definition used to find aerodynamic diameter. It states "AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO THE TASK GROUP ON LUNG DYNAMICS" if code variable MAERO is input as a nonpositive integer, or if the first calculations of D_{50}'s, cumulative mass loadings, etc., are being made and the density was input as 1.0 gram per cubic centimeter regardless of input value of MAERO. It states "AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO MERCER" if code variable MAERO is input as a positive integer and this is the second calculation of D_{50}'s, cumulative mass loadings, etc., for this set of data.

Note: The programming on cards 554-616 is executed to find maximums and minimums of all plotted variables for this single run at the indicated assumed density. These values are later compared to maximums and minimums of all other runs at the indicated assumed density to find overall maximum and minimum values (see calculations on cards 751-781). This enables one to make "data regulated" graphs if desired, *i.e.*, the number and range of cycles may be regulated according to the span of data.

554-573: Search the values of cumulative mass loading in milligrams per actual cubic meter, $CUMG_I$, I = 1,NC, for the minimum value. Express it as an element in the run-indexed array, $CUMGF_{IS}$. Since the values in array $CUMG_I$ are decreasing with higher index, the search consists of finding the last nonzero value of $CUMG_I$. For example, unless the last cumulative mass loading value, $CUMG_{NC}$, is zero:

$$CUMGF_{IS} = CUMG_{NC}$$

If this value is zero and $CUMG_{NC-2}$ is not zero:

$$CUMGF_{IS} = CUMG_{NC-1}$$

The number of cumulative mass loadings less than D_{50} which must be searched for a given run, NC, is the same as the number of stage D_{50} values + 1 for the cyclone (if applicable). This value is NCUM = 8 for the Andersen impactor or NCUM = 7 for the University of Washington or the MRI impactor. For the Brink impactor, the configuration may vary. Therefore, NC = MS + M00 + MC3 where MS = index of last stage(5 or 6); M00 = 1 if stage 0 is included, or M00 = 0 if stage 0 is not included; and MC3 = 0 if the cyclone is included or MC3 = 1 if the cyclone is not included.

574: Express the total mass loading in milligrams per actual cubic meter, GRNAM, as an element in the run indexed array, $CUMG1_{IS}$:

$$CUMG1_{IS} = GRNAM \qquad (47)$$

575-579: Search the values of the stage D_{50}'s in micrometers, DPC_I, I = 1,ND, to find the minimum nonzero value. Express it as an element in the run-indexed array, $DPCF_{IS}$. As with $CUMG_I$, I = 1,NC, the values are decreasing with higher index. Thus, unless DPC_{ND} is zero:

$$DPCF_{IS} = DPC_{ND} \tag{48}$$

The number of D_{50} values to be searched for a given run, ND, is NCUM as defined above for the Andersen, the University of Washington, or the MRI impactor. If the Brink impactor is used, the configuration determines the value of ND. ND = MS + M00, where MS and M00 are defined above in determining NC.

580: Express the diameter of the maximum captured particle in micrometers, DMAX, as an element in the run indexed array, $DMAXX_{IS}$:

$$DMAXX_{IS} = DMAX \tag{49}$$

581-591: Search the values of the geometric mean diameter at each stage in micrometers, $GEOMD_I$, I = 1,NMASS, to find minimum nonzero value. Express it as an element in the run-indexed array, $GDMIN_{IS}$. Again, the values are decreasing with higher index. Thus, unless $GEOMD_{NMASS}$ is zero:

$$GDMIN_{IS} = GEOMD_{NMASS} \tag{50}$$

592: Express the maximum geometric mean diameter in micrometers, $GEOMD_1$ as an element in the run-indexed array, $GDMAX_{IS}$. $GEOMD_1$ must be the value of maximum geometric mean diameter since the values of $GEOMD_I$, I = 1,NMASS are decreasing with increasing I. Thus:

$$GDMAX_{IS} = GEOMD_1 \tag{51}$$

593-600: Search the values of ΔM/ΔLogD size distribution in milligrams per dry normal cubic meter, $DMDLD_I$, I = 1,NMASS, to find the minimum nonzero value. Express it as an element in the run-indexed array, $DMMN_{IS}$. Note that unlike the previous "searches" for minimums and maximums, this value may be any one of the values between $DMDLD_1$ and $DMDLD_{NMASS}$.

601-604: Search the values of the ΔM/ΔLogD size distribution in milligrams per dry normal cubic meter, $DMDLD_I$, I = 1,NMASS, to find the maximum value. Express it as an element in the run-indexed array, $DMMX_{IS}$.

605-612: Search the values of ΔN/ΔLogD size distribution in number per dry normal cubic meter, $DNDLD_I$, I = 1,NMASS, to find the minimum nonzero value. Express it as an element in the run-indexed array, $DNMN_{IS}$.

613-616: Search the values of the ΔN/ΔLogD size distribution in number per dry normal cubic meter, $DNDLD_I$, I = 1,NMASS, to find the maximum value. Express it as an element in the run-indexed array, $DNMX_{IS}$.

617-626: VARD is a one-dimensional array consisting of the maximum particle diameter, DMAX, the cut point of the cyclone, CYC3, (if Brink impactor with cyclone is used), D_{50} of the first stage,...,D_{50} of the last stage all in micrometers in this order. The first VARD value is defined here:

$$VARD_1 = DMAX \tag{52}$$

VARC is a one-dimensional array consisting of the total mass loading, GRNAM, mass loading < cut point of the cyclone (if Brink impactor with cyclone is used); mass loading < D_{50} (first stage),..., mass loading < D_{50} (last stage) all milligrams per actual cubic meter. The first VARC value is defined here:

$$VARC_1 = GRNAM \qquad (53)$$

627: The VARC and VARD arrays are being defined in order to define the XNDPEN and YO arrays which will be used by program SPLIN1 for curve fitting. The remainder of the VARD and VARC arrays is dependent on the impactor used and its configuration. This statement sends the program to statement 6300 (card 634) if the Andersen impactor is being used (MPACTY=1), to statement 6350 (card 642), if the Brink impactor is being used (MPACTY=2); or to statement 6375 (card 663), if the University of Washington or MRI impactor is being used (MPACTY=3 or MPACTY=4, respectively).

628-641: The program comes to this section to define the remaining VARD and VARC values, if the Andersen impactor is being used. There are eight stage D_{50} values, DPC, and eight associated cumulative mass loading values, CUMG, with which to complete the VARD and VARC arrays, respectively. However, the cut points of the first and second stages are so nearly the same that a more realistic view of mass distribution can be obtained by ignoring the D_{50} and associated cumulative mass loading of the second stage. Thus, only seven more values are added to the VARD and VARC arrays:

$$VARD_2 = DPC_1;\ VARC_2 = CUMG_1$$

$$VARD_3 = DPC_3;\ VARC_3 = CUMG_3$$

$$VARD_4 = DPC_4;\ VARC_4 = CUMG_4$$

$$\vdots \qquad \vdots \qquad \vdots \qquad \vdots \qquad \vdots \qquad \vdots$$

$$VARD_8 = DPC_8;\ VARC_8 = CUMG_8$$

VV is the total number of VARD and VARC values. For the Andersen impactor, VV = 8. The program then skips to statement 6400 (card 675) to set up the XNDPEN and YO arrays which program SPLIN1 uses for fitting cumulative mass loading vs. D_{50}.

642-662: The program comes to this section to define the remaining VARD and VARC values if the Brink impactor is being used. In this case the impactor configuration also determines the values of the two arrays. If the cyclone is used, its cut point, CYC3, becomes the second value of the VARD array $VARD_2$. If stage 0 is the first stage (without the cyclone), then its cut point $DPC_1 = VARD_2$. If neither the cyclone nor stage 0 is included, the cut point of stage 1, $DPC_2 = VARD_2$. (Whatever the configuration here, the first cumulative mass loading value, $CUMG_1$, is the cumulative mass loading of the first "stage" whether this be the cyclone, stage 0, or stage 1). Therefore, $VARC_2 = CUMG_1$. The VARD and VARC values are defined consecutively after this with the values of DPC and CUMG. The total number of values in the VARD and VARC arrays VV = 1 + MC3 + MOO + MS where MC3 = 1 when the cyclone is used or 0 when it is not, MOO = 1 when stage 0 is used or 0 when it is not, and MS = last stage of the Brink impactor = 5 or 6. After defining all VARD and VARC values, the program skips to statement 6400 (card 675) to define the XNDPEN and YO arrays used for fitting in program SPLIN1.

663-669: The program comes to this section to define the remaining VARD and VARC values if the University of Washington or the MRI impactor is being used. In this case there are seven stage D_{50}'s, DPC, with seven associated cumulative mass loadings, CUMG. However, as with the Andersen impactor, the cut points of the first and second stages of the University of Washington and MRI impactors are so nearly the same that a more realistic view of mass distribution can be obtained by ignoring the D_{50} and associated cumulative mass loading of the second stage. The VARD and VARC arrays, therefore, are completed with these values:

$$\begin{aligned} VARD_2 &= DPC_1;\ VARC_2 = CUMG_1 \\ VARD_3 &= DPC_3;\ VARC_3 = CUMG_3 \\ \vdots\ \ &\ \ \vdots \qquad\quad \vdots\qquad\ \ \vdots \\ VARD_7 &= DPC_7;\ VARC_7 = CUMG_7 \end{aligned}$$

The total number of VARD and VARC values, VV, is then 7.

670-685: The fitting arrays XNDPEN and YO are defined here. The values are the same as the VARD and VARC arrays, respectively, except that any pair of values $(VARD, VARC)_J$ where either $VARD_J$ or $VARC_J$ is zero is excluded from the XNDPEN *and* YO arrays. For example, since the values of VARD represent maximum particle diameter, cut points of the cyclone (this value is included *only* if the Brink is used with the cyclone), and stage cut points, there are no VARD values equal to zero. However, if no mass is collected on the filter, $VARC_{VV} = 0.0$ where VV is the total number of VARD and VARC values. In this case the XNDPEN and YO arrays have one less value in them than the VARD and VARC arrays. This number of values in the XNDPEN and YO arrays is then NFIT = VV - 1.

686-697: Here the VARD and VARC arrays are redefined as the XNDPEN and YO arrays, respectively, with inverted order. Using the newly ordered VARD and VARC arrays, the XNDPEN and YO arrays are also reordered; *i.e.*, $(XNDPEN, YO)_1$ is the point representing the last (smallest) stage cut point diameter and cumulative mass loading less than this stage cut point (where the mass loading is nonzero); and $(XNDPEN, YO)_{NFIT}$ is the point representing the maximum particle diameter and total mass loading. Values of XNDPEN are in micrometers. Values of YO are in grams per actual cubic meter.

698-716: The order of $XNDPEN_I$, I = 1,NFIT and YO_I, I = 1,NFIT should be such that both are increasing with I. However, it has been found empirically by Southern Research Institute that the cut point of the first stage of the University of Washington impactor may actually be less than that of the second stage. The program SPLIN1 cannot make a proper fit to the (XNDPEN, YO) points in such a case. This loop, therefore, checks the XNDPEN array and orders it. The values of YO_I, I = 1,NFIT are reordered to follow XNDPEN, *i.e.*, the pairing of (XNDPEN, YO) is not changed.

717-720: The smallest stage D_{50} for this run $XNDPEN_1$ is given the name DSMA. This value will be the starting diameter for plotting the curve fit through cumulative mass loading vs. D_{50} points in the program GRAPH.

721-726: Define the total number of points to be plotted for the plot of cumulative mass loading vs. D_{50}, JV. This does not exclude any points with zero cumulative mass loading. It does exclude the total mass loading vs. maximum particle diameter.

727-734: Write on file any variable values from this single run which will be needed in later programs SPLIN1, GRAPH, and STATIS.

735-740: This loop changes the percent flue gas composition values, FG_I, I = 1,5, back to fractional flue gas composition:

$$FG_I = FG_I/100.0,\ I = 1,5$$

(Recall that these fractions represent CO_2, CO, N_2, O_2, and H_2O, respectively.

741-750: Check the record number, IS, for the calculations above. If IS is odd ((IS+1)/2-IS/2=1), these are the first calculations of D_{50}'s, cumulative mass loadings, etc., for this set of data (may be based on physical density or unit density). In this case the program goes to statement 2020 (card 748) to save the input density values as RHO1, define density RHO as the unit value 1.0 gram per cubic centimeter, and return to statement 2010 (card 193) to make similar calculations based on this unit density. These new D_{50} values, cumulative mass loading values, etc., are found based on the TGLD definition[1] of aerodynamic diameter if NAERO is 0 or based on Mercer's definition[2] if NAERO is 1. If IS is even [(IS+1)/2-IS/2=0], these second calculations have just been made and the program returns to statement 12 (card 76) to read a new set of data.

751-781: If data for all runs has been read in and appropriate calculations made on each for both densities, the program returns to statement 93 (card 758) to calculate the overall (for all runs) maximum and minimum values of every plotted variable for each of the two densities. As discussed in the note preceeding explanation at card 554, the maximum and minimum values will allow for data regulated plots, if desired. The variables which are searched for are defined below. Although not indicated here, each is dimensioned two; one value for each of the two densities.

DPMIN - minimum stage D_{50} in micrometers; to be found in the $DPCF_{IS}$ array.

DPMAX - maximum particle diameter in micrometers; to be found in the $DMAXX_{IS}$ array

CUMIN - minimum cumulative mass loading value in milligrams per actual cubic meter; to be found in the $CUMGF_{IS}$ array

CUMAX - maximum cumulative mass loading or maximum total mass loading in milligrams per actual cubic meter; to be found in the $CUMG1_{IS}$ array

GEMIN - minimum geometric mean diameter in micrometers; to be found in the $GDMIN_{IS}$ array

GEMAX - maximum geometric mean diameter in micrometers; to be found in the $GDMAX_{IS}$ array

DMMIN - minimum value of the $\Delta M/\Delta LogD$ size distribution in milligrams per dry normal cubic meter; to be found in the $DMMIN_{IS}$ array

DMMAX - maximum value of the $\Delta M/\Delta LogD$ size distribution in milligrams per dry normal cubic meter; to be found in the $DMMX_{IS}$ array

DNMIN - minimum value of the ΔN/ΔLogD size distribution in number of particles per dry normal cubic meter; to be found in the $DNMN_{IS}$ array

DNMAX - maximum value of the ΔN/ΔLogD size distribution in number of particles per dry normal cubic meter; in the $DNMX_{IS}$ array.

For example, the $DPMIN_I$ value is found by arbitrarily setting it equal to $DPCF_1$. This is the minimum D_{50} value of the first odd record. This temporary $DPMIN_1$ is compared with all the other $DPCF_{IS}$ values where IS is odd. Each time a smaller $DPCF_{IS}$ value is found, that $DPCF_{IS}$ value becomes the new $DPMIN_1$. This process is continued until all values have been checked to arrive at the absolute minimum D_{50} value for all physical density runs. All other minimum values are found in this manner. A similar "bubble up" method is used to find the maximums.

782-788: Write variable values on file which may be needed in later programs. These include the minimum and maximum values just found.

789: Stop.

Functions of the Called Subprograms

Subroutine STAGE--

This subroutine consists of a simple DO loop at cards 010-012. It calculates the local pressure at each stage of the impactor in atmospheres PS_I, I = 1,NCUM as a function of the pressure at the impactor orifice in atmospheres, POA; the cumulative fraction of pressure drop at stage I (depending on the impactor used as indicated by code value MPACTY), $DELP_{I,MPACTY}$; and the total drop in pressure across the impactor in atmospheres, DPA:

$$PS_I = POA - DELP_{I,MPACTY} \cdot DPA$$

POA and DPA are brought into the subroutine as calculated in the calling mainline program MPPROG. The values of the DELP matrix are initialized in the block data subprogram COMBK1.

Subroutine VIS--

This subroutine calculates the viscosity of the gas in poise, MU, by a method proposed by C. R. Wilke.[4]

017-024: Calculate the pure gas viscosities of the gases composing the flue gas in poise, VS_I, I = 1,5, where these gases are CO_2, CO, N_2, O_2, and H_2O for I = 1,5, respectively. These viscosities are functions of the impactor temperature in degrees centigrade, TCI:

$$VS_I = K_{I1} + [K_{I2}(TCI)] + [K_{I3}(TCI)^2] + [K_{I4}(TCI)^3] \quad (55)$$

where K_{IJ}, I = 1,5 (gas index), J = 1,4 are constants (see discussion of gas viscosities in Sec. 1).

025-026: A small DO loop converts the pure gas viscosities, VS_I, I = 1,5, from micropoise to poise so that the final gas viscosity, MU, is in poise:

$$VS_I = VS_I \times 10^{-6}$$

027: The gas viscosity MU is initialized as 0.0 poise.

028-031: The pure gas fractional contributions, FG_I, I = 1,5, (for CO_2, CO, N_2, O_2, and H_2O, respectively) are examined here in a DO loop. Any pure gas which has zero contribution to the flue gas composition has its fractional contribution FG_I set equal to an arbitrary extremely small number to prevent division by zero in succeeding calculations:

$$FG_I = 1.0 \times 10^{-20} \qquad (56)$$

where previously $FG_I = 0.0$.

032-045: The flue gas viscosity MU is calculated in poise here. MU is calculated as a function of the pure gas viscosities in poise VS_I, I = 1,5 as calculated at cards 017-027, the pure gas molecular weights in atomic mass units WT_I, I = 1,5 for CO_2, CO, N_2, O_2, and H_2O, respectively, as given in a data statement at card 016, and these pure gas fractional contributions FG_I, I = 1,5 as brought from mainline program MPPROG (with exception of $FG_I = 0.0$ as altered at cards 028-030):

$$MU = \sum_{I=1}^{5} \frac{VS_I}{1.0 + (1/FG_I) \displaystyle\sum_{\substack{J=1 \\ J \neq I}}^{5} (FG_J)\ (X\Phi_{IJ})} \qquad (57)$$

$$\text{where } X\Phi_{IJ} = \frac{\left\{1.0 + (VS_I/VS_J)^{1/2}\ (WT_J/WT_I)^{1/4}\right\}^2}{(4/1.414)\ \left[1.0+(WT_I/WT_J)\right]^{1/2}} \qquad (58)$$

Subroutine MEAN--

This subroutine consists of a simple DO-loop at cards 012-014 which calculates the molecular mean free path at each stage jet, L_I, I = 1,NCUM, by a method proposed by J. A. Brink, Jr.,[3] as a function of the gas viscosity in poise, MU, the local pressure at this stage I in atmospheres, PS_I, the impactor temperature in degrees Kelvin, TKI (as brought from the mainline program MPPROG), and the mean molecular weight in atomic mass units, MM (as brought from the mainline program MPPROG):

$$L_I = \frac{}{1.01325\ 10^6\ PS_I} \left(\frac{BZ\ TKI\ 602.3 \times 10^{21}}{8\ MM}\right)^{1/2} \tag{59}$$

where $BZ = 1.38 \times 10^{-16} \times 3.14159$

= Boltzmann's constant (erg/°K) x π

Subroutine CUT--

This subroutine consists of an iterative loop at cards 033-046 which calculates the stage cut points or D_{50}'s in micrometers, DPC_I, I = 1,NCUM, based on equations developed by Ranz and Wong.[7] Each DPC_I is calculated as a function of the calibration constants, $SRPSI_{I,MPACNO,MPACTY}$, the gas viscosity in poise, MU, the number of jets per stage, $X_{I,MPACTY}$, and the stage jet diameter, $DC_{I,MPACNO,MPACTY}$, the local pressure at stage I in atmospheres, PS_I, the assumed density in grams per cubic centimeter, RHO, gas flow rate under impactor conditions in actual cubic feet per minute, Q, the pressure at the impactor orifice in atmospheres, POA, and the slip correction factor, C (see below):

$$DPC_I = \left[\frac{1.43 \times 10^4}{0.38}\ SRPSI_{I,MPACNO,MPACTY}\right] \times \left[\frac{MU\ X_{I,MPACTY}\left(DC_{I,MPACNO,MPACTY}\right)^3\ PS_I}{RHO\ Q\ 472.0\ POA\ C}\right]^{1/2} \tag{60}$$

The square root of psi calibration constants, $SRPSI_{I,MPACNO,MPACTY}$, are empirical constants measured for each impactor. These conconstants were determined according to the published procedures of Seymour Calvert,[8] et al, and of Kenneth M. Cushing,[9] et al. These values are shown in Tables 4, 5, 6, and 7. (The user should insert his own calibration constants.) The index I-1,NCUM is the stage index. The index MPACTY is impactor type coding where MPACTY = 1 indicates that the Andersen impactor is used, MPACTY = 2 indicates the Brink, MPACTY = 3 indicates the University of Washington, or MPACTY = 4 indicates the MRI. MPACNO is coding for the impactor number within a type.

TABLE 4. $\sqrt{\psi}$ CALIBRATION CONSTANTS FOR EACH STAGE OF SIX ANDERSEN IMPACTORS[a]

Impactor no.: Stage no.	I	229 $SRPSI_{I11}$	231 $SRPSI_{I21}$	583 $SRPSI_{I31}$	619 $SRPSI_{I41}$	620 $SRPSI_{I51}$	627 $SRPSI_{I61}$
0	1	0.305	0.305	0.305	0.305	0.305	0.305
1	2	0.430	0.430	0.430	0.430	0.430	0.430
2	3	0.410	0.410	0.410	0.410	0.410	0.410
3	4	0.385	0.385	0.385	0.385	0.385	0.385
4	5	0.328	0.332	0.341	0.342	0.337	0.344
5	6	0.319	0.313	0.320	0.370	0.331	0.335
6	7	0.364	0.365	0.331	0.352	0.350	0.339
7	8	0.283	0.280	0.274	0.272	0.277	0.278

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[a] A maximum of 6 impactors of this type can be used.

TABLE 5. $\sqrt{\psi}$ CALIBRATION CONSTANTS FOR EACH STAGE OF FOUR BRINK IMPACTORS[a]

Impactor no.:		A	B	C	D	none	none
Stage no.	I	$\mathrm{SRPSI}_{I_{12}}$	$\mathrm{SRPSI}_{I_{22}}$	$\mathrm{SRPSI}_{I_{32}}$	$\mathrm{SRPSI}_{I_{42}}$	$\mathrm{SRPSI}_{I_{52}}$	$\mathrm{SRPSI}_{I_{62}}$
0	1	0.322	0.322	0.322	0.322	0.000	0.000
1	2	0.322	0.322	0.322	0.322	0.000	0.000
2	3	0.338	0.349	0.351	0.346	0.000	0.000
3	4	0.345	0.330	0.388	0.354	0.000	0.000
4	5	0.258	0.302	0.330	0.297	0.000	0.000
5	6	0.317	0.345	0.350	0.337	0.000	0.000
6	7	0.229	0.175	0.273	0.226	0.000	0.000
none	8	0.000	0.000	0.000	0.000	0.000	0.000

---

a. A maximum of 6 impactors of this type can be used.

TABLE 6. $\sqrt{\psi}$ CALIBRATION CONSTANTS FOR EACH STAGE OF FOUR UNIVERSITY OF WASHINGTON MARK III IMPACTORS[a]

Impactor no.: Stage no.	I	A $SRPSI_{I13}$	B $SRPSI_{I23}$	C $SRPSI_{I33}$	D $SRPSI_{I43}$	none $SRPSI_{I53}$	none $SRPSI_{I63}$
1	1	0.144	0.144	0.144	0.144	0.000	0.000
2	2	0.330	0.330	0.330	0.330	0.000	0.000
3	3	0.371	0.371	0.371	0.371	0.000	0.000
4	4	0.271	0.322	0.320	0.319	0.000	0.000
5	5	0.308	0.313	0.295	0.321	0.000	0.000
6	6	0.373	0.340	0.363	0.389	0.000	0.000
7	7	0.349	3.337	0.312	0.354	0.000	0.000
none	8	0.000	0.000	0.000	0.000	0.000	0.000

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a. A maximum of 6 impactors of this type can be used.

TABLE 7. $\sqrt{\psi}$ CALIBRATION CONSTANTS FOR EACH STAGE OF ONE METEOROLOGY RESEARCH INCORPORATED IMPACTOR[a]

Impactor no.:		A	none	none	none	none	none
Stage no.	I	SRPSI_{I14}	SRPSI_{I24}	SRPSI_{I34}	SRPSI_{I44}	SRPSI_{I54}	SRPSI_{I64}
1	1	0.11	0.00	0.00	0.00	0.00	0.00
2	2	0.25	0.00	0.00	0.00	0.00	0.00
3	3	0.35	0.00	0.00	0.00	0.00	0.00
4	4	0.34	0.00	0.00	0.00	0.00	0.00
5	5	0.29	0.00	0.00	0.00	0.00	0.00
6	6	0.35	0.00	0.00	0.00	0.00	0.00
7	7	0.40	0.00	0.00	0.00	0.00	0.00
8	none	0.00	0.00	0.00	0.00	0.00	0.00

---

[a] A maximum of 6 impactors of this type can be used.

The value of the slip correction factor C depends on the definition of the cut point diameter being calculated. It may be a function of DPC_I or it may be given the value 1.0, i.e., C may be a factor.

If physical density is assumed (RHO>1.0) or where the classically defined (TGLD) aerodynamic diameter is assumed (NAERO = 0 and RHO=1.0), an iterative process is necessary to find each of the DPC values, since C is defined as a function of DPC_I and also as a function of the mean free path at this stage in centimeters, L_I:

$$C = 1 + \frac{2L_I}{DPC_I \times 10^{-4}} \left[1.23 + 0.41 \exp\left(-0.44\ DPC_I \times 10^{-4}/L_I\right)\right] \quad (61)$$

In this case, each DPC_I must be given an initial value $SUB_{I,MPACTY}$ in order to begin the iterative process. Each value of DPC_I is compared to DPCI which is the previously calculated value of DPC_I. If the two values are within 0.1% of each other (as checked at card 044), the iterative calculation of DPC_I is said to have converged, and the program returns to the beginning of this loop to calculate the D_{50} of the next stage.

If aerodynamic diameter by Mercer's definition is assumed (NAERO=1 and RHO=1.0), the slip correction factor is essentially not used. Rather than being a functional quantity, it is the constant 1.0. In this case the first calculation of DPC_I is the same as the second calculation, and iteration is not necessary.

If the Brink impactor is used (MPACTY=2), the lower cut point for the cyclone, CYC3, is calculated in micrometers as a function of the gas viscosity is poise, MU, the assumed density in grams per cubic centimeter, RHO, and the gas flow rate under impactor conditions in actual cubic feet per minute, Q:

$$CYC = 199.5\ (MU/RHO\ Q)^{1/2} \quad (62)$$

Note that the slip correction factor is not a factor here for any assumed density. This is due to the fact that C becomes very nearly 1.0 for large diameters. For example, assuming a mean free path of 6.53×10^{-6} centimeters, the following values of C for given cut points are:*

Particle diameter (µm)	C
10	1.0164
20	1.0082
30	1.0055
50	1.0033
100	1.0016

Subroutine CUM--

This subroutine calculates the cumulative mass less than the D_{50} of the previous stage in grams, $CUMM_I$, I = 1,NMASS ($CUMM_{NMASS}$ = SUM = total mass) and the cumulative percent mass less than the D_{50} of the previous stage, $PERCU_I$, I = 1,NMASS ($PERCU_{NMASS}$ = 100.0%). Also calculated are the total mass loading in grains per actual cubic foot, GRNA, in grains per normal dry cubic foot, GRNS, in milligrams per actual cubic meter, GRNAM, and in milligrams per normal dry cubic meter, GRNSM. Note that normal (or engineering standard) conditions here are 21 degrees centigrade and 760 millimeters of mercury.

013-016: After initializing the sum of masses, SUM, as 0.0 grams, the "DO 50" loop here finds the cumulative mass at each stage in grams, $CUMM_I$, I = 1,NMASS, by summing the masses $MASS_I$ on all stages up to and including the I^{th} stage:

$$CUMM_J = \sum_{I=1}^{J} (MASS_I) \qquad (62)$$

where J = 1,NMASS

---

* These values are taken from the chart "Tables for Use in Aerosol Physics" printed by BGI Incorporated, copyright 1971.

After NMASS traverses of the loop:

$$\text{SUM} = \sum_{I=1}^{\text{NMASS}} (\text{MASS}_I) \quad (63)$$

which is the sum of all masses or the total mass captured in the impactor in grams

017-019: This loop converts the cumulative mass at each stage in grams CUMM_I I = 1,NMASS to cumulative percent of total mass captured (SUM), PERCU_I, I = 1,NMASS:

$$\text{PERCU}_J = \sum_{I=1}^{J} [(\text{CUMM}_I/\text{SUM})\ 100.0] \quad (64)$$

020-023: The total mass loading in grains per actual cubic foot, GRNA, is calculated here as a function of the total captured mass in grams, SUM, gas flow rate under stack conditions in actual cubic feet per minute, F, and the duration of sampling time in minutes, DUR.

$$\text{GRNA} = \text{SUM}\ 15.4324/\text{F DUR}$$

The constant 15.4324 = grains/gram

024-027: The total mass loading in grains per normal dry cubic foot, GRNS, is calculated here as a function of the total mass captured in grams, SUM, the gas flow rate under stack conditions in actual cubic feet per minute, F, the duration of sampling in minutes, DUR, the pressure at the impactor inlet in atmospheres, POA, the stack temperature in degrees Kelvin, TKS, and the fractional water content, FG_1:

$$\text{GRNS} = \frac{\text{SUM}\ 15.4324}{\text{F DUR}\ (294.0/\text{TKS})\ \ (\text{POA}/1.0)\ (1.0-\text{FG}_1)} \quad (65)$$

The units of constants here are:

15.4324 = grains/gram

294.0 = degrees Kelvin = 21 degrees Centigrade

1.0 = 1 atmosphere

028-032: The total mass loading in milligrams per actual cubic meter, GRNAM, is calculated here as a function of the total mass loading in grains per actual cubic foot, GRNA:

$$\mathrm{GRNA} = 2288.34\ \mathrm{GRNA} \tag{66}$$

The constant $2288.34 = \dfrac{\text{milligrams/grain}}{\text{cubic meters/cubic foot}}$

033-037: The total mass loading in milligrams per normal dry cubic meter, GRNSM, is calculated here as a function of the total mass loading in grains per normal dry cubic foot, GRNS:

$$\mathrm{GRNSM} = 2288.34\ \mathrm{GRNS} \tag{67}$$

The constant 2288.34 has units as given above.

Subroutine DMDNGD--

This subroutine calculates and prints out the set of stage geometric mean diameters in micrometers, GEOMD, the ΔM/ΔlogD values in milligrams per dry normal cubic meter, DMDLD, and the ΔN/ΔlogD values in number of particles per dry normal cubic meter, DNDLD. The technique for finding these values and the printout format varies only slightly depending on the type of impactor and, if using the Brink impactor, also on the impactor configuration. The statement at card 037 sends the program to the proper section of the subroutine depending on the impactor used (controlled by coding MPACTY = 1 for Andersen, 2 for Brink, 3 for University of Washington, and 4 for MRI). Cards 038-137 comprise a long section which calculates the GEOMD, DMDLD, and DNDLD values for the Brink impactor of any configuration and prints out these values. If the cyclone, stage 0, stage 1,..., stage 5, or stage 6 and filter are used in the Brink, cards 043-081 are executed. If stage 0, stage 1, stage 2,..., stage 5, or stage 6, and filter are used in the Brink, cards 082-110 are used. If stage 1, stage 2, stage 3, stage 4, stage 5, or stage 6, and filter configuration are used in the Brink, cards 111-138 are executed. There is only one configuration for the Andersen impactor, i.e., stage 0, stage 1, stage 2,..., stage 7, and filter. Also, there is only one configuration for the University of Washington or MRI, i.e., stage 1, stage 2, stage 3,..., stage 7, and filter. Cards 139-162 comprise the section which calculates and prints out the GEOMD, DMDLD, and DNDLD values for the Andersen, the University of Washington, or the MRI impactor. For each of these six configurations, there are five sets of values found.

The value $DIFF_I$ is defined in a loop for each stage as being the difference in the common logs of the cut point diameter of the previous stage I - 1 and this stage I. $DIFF_1$, however, must be calculated outside this loop since there is no "cut point diameter of the previous stage". Here the common log of the maximum particle diameter DMAX is used instead. If the Brink impactor is used with the cyclone, $DIFF_2$ must also be calculated outside this loop. In this case, $DIFF_2 = \log_{10}(CYC3 - \log_{10}(DPC(1))$, i.e., the name for the cut point of the cyclone is CYC3 and is not part of the ordinary D_{50} array DPC. Also, for each configuration, the final value of $DIFF_{NS}$ must be given outside the loop since there is no lower cut point for this "stage" (actually the filter). For each configuration, $DIFF_{NS}$ is defined as $\log_{10}2 = 0.3010$. This is a somewhat arbirary asigned value; however, it has been found that the $\log_{10}$ difference of consecutive D_{50}'s is within this range.

The next set of values calculated for each configuration is the $\Delta M/\Delta \log D$ value at each stage in milligrams per normal dry cubic meter, $DMDLD_I$, as a function of the common log difference in lower cut point diameters $DIFF_I$ (as found above) and the mass loading for this stage in milligrams per actual cubic meter $GGRNS_I$ as brought from the mainline program MPPROG:

$$DMDLD_I = GGRNS_I/DIFF_I \tag{68}$$

The geometric mean diameter in micrometers, $GEOMD_I$, is then found for each stage (including the cyclone if used and the filter). This is the average of the logs of the maximum and minimum particle sizes found on the stage. It is calculated here as the square root of the minimum cut point particle size of this stage times the minimum cut point particle size of the previous stage I - 1 (this latter particle size being an upper limit of particle size for stage I). As in calculating the DIFF values, there is no "lower cut point diameter of the previous stage" when finding $GEOMD_1$. Therefore, $GEOMD_1$ = the square root of the maximum particle diameter in micrometers, DMAX, times the lower cut point particle size of this first stage (or cyclone if used). Also, as in finding the last value of DIFF, the GEOMD of the filter must be found in a different manner since there is no lower cut point diameter for the filter. It is found by multiplying the lower cut point diameter of the previous stage by $1/\sqrt{2} = 0.707107$. (This is again the result of defining the difference in the log of the last stage D_{50} and the log of the "filter D_{50}" as log 2.)

The next set of values calculated for each configuration is the $\Delta N/\Delta \log D$ value at each stage in number of particles per normal dry cubic meter, $DNDLD_I$, as a function of the $\Delta M/\Delta \log D$ value at the stage in milligrams per dry normal cubic meter, $DMDLD_I$, the assumed density in grams per cubic centimeter, RHO, and the geometric mean diameter of the stage in micrometers $GEOMD_I$. To show the development of this function for DNDLD, note that $\Delta M/\Delta \log D$ may be written as:

$$\Delta M/\Delta \log D = \Delta(Nm)/\Delta \log D \qquad (69)$$

$$= m(\Delta N)/\Delta \log D$$

where m = mass of a single particle

$\Delta N/\Delta \log D$ = change in number concentration due to particles caught on this stage

Then $\Delta N/\Delta \log D$ may be expressed as:

$$\Delta N/\Delta \log D = (\Delta M/\Delta \log D)/m \qquad (70)$$

Also the single particle mass m may be expressed as:

$$m = \rho \left(\frac{\pi D^3}{6}\right) (10^3) \ (10^{-4})^3 \qquad (71)$$

where ρ = particle density in grams per cubic centimeter

$\frac{\pi D^3}{6}$ = volume in cubic micrometers of a particle with diameter D in micrometers

10^3 = milligrams/gram

10^{-4} = centimeter/micrometer

Therefore:

$$\Delta N/\Delta \log D = (\Delta M/\Delta \log D) \ [6/(\rho \pi D^3)]10^9 \qquad (72)$$

In terms of the program:

$$\mathrm{DNDLD} = \mathrm{DMDLD}[6/(\mathrm{RHO}\ \pi\ \mathrm{GEOMD}^3)]10^9 \qquad (73)$$

The final part of each configuration section is the printing of the GEOMD, DMDLD, and DNDLD values. Each of the six configurations has its own format. The subroutine then returns to the calling mainline program MPPROG.

Block Data Subprogram COMBK1--

COMBK1 is a block data subprogram. It is used to define the values of the cumulative fraction of pressure drop DELP.* DELP is a two dimensional real array with elements $\text{DELP}_{I,J}$. The first dimension I specifies the stage of the impactor. The second dimension J specifies the type of impactor (same as code variable MPACTY where 1 indicates the use of the Andersen impactor, 2 indicates the use of the Brink impactor, 3 indicates the use of the University of Washington impactor, and 4 indicates the use of the MRI impactor). The values of fractional pressure drop used in this subprogram are empirically determined and are listed in Table 8. Note that even though there are only 7 stages for the Brink, University of Washington, and MRI impactors, a dummy value of 0.0 for $\text{DELP}_{8,2}$, $\text{DELP}_{8,3}$, and $\text{DELP}_{8,4}$ must be used to keep proper ordering in the 8x4 DELP array.

Block Data Subprogram COMBK2--

COMBK2 is a block data subprogram. It is used to define the number of jets per stage, X, and to define the diameter of the jets at each stage in centimeters, DC.**

X is a two dimensional integer array with elements $X_{I,J}$. The first dimension I indicates the stage of the impactor. The second dimension J indicates the type of impactor. The number of jets per stage as specified in COMBK2 are given in Table 9. Note that even though there are only 7 stages for the Brink, University of Washington, and MRI impactors, a dummy value of 0 for $X_{8,2}$,

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*The DELP values are used as a part of common block BLOCK1. Variable values in a data statement must be initialized in a block data subprogram for any information to be carried in the specified common block as required by the DEC PDP 15/76 computer system used by Southern Research Institute.

**The X and DC values are used as a part of common block BLOCK2. Variable values in a data statement must be initialized in a block data subprogram for any information to be carried in the specified common block as required by the DEC PDP 15/76 computer system used by Southern Research Institute.

TABLE 8. VALUES OF FRACTIONAL PRESSURE DROP USED IN COMBK1

	Andersen		Brink		Univ. of Wash.		MRI	
I	Stage no.	$DELP_{I,1}$	Stage no.	$DELP_{I,2}$	Stage no.	$DELP_{I,3}$	Stage no.	$DELP_{2,4}$
1	0	0.000	0	0.000	1	0.000	1	0.000
2	1	0.000	1	0.004	2	0.000	2	0.000
3	2	0.000	2	0.008	3	0.000	3	0.000
4	3	0.000	3	0.014	4	0.000	4	0.000
5	4	0.000	4	0.045	5	0.057	5	0.045
6	5	0.176	5	0.143	6	0.566	6	0.216
7	6	0.294	6	1.000	7	1.000	7	1.000
8	7	1.000	none	0.000	none	0.000	none	0.000

TABLE 9. NUMBER OF JETS PER STAGE FOR ANDERSEN, BRINK, UNIVERSITY OF WASHINGTON, AND MRI IMPACTORS

I	Andersen Stage no.	$X_{I,1}$	Brink Stage no.	$X_{I,2}$	Univ. of Wash. Stage no.	$X_{I,3}$	MRI Stage no.	$X_{I,4}$
1	0	264	0	1	1	1	1	8
2	1	264	1	1	2	6	2	12
3	2	264	2	1	3	12	3	24
4	3	264	3	1	4	90	4	24
5	4	264	4	1	5	110	5	24
6	5	264	5	1	6	110	6	24
7	6	264	6	1	7	90	7	12
8	7	156	none	0	none	0	none	0

$X_{8,3}$, and $X_{8,4}$ must be used to keep proper ordering in this 8x4 array.

DC is a three dimensional real array with elements DC_{IJK}. The first dimension I indicates the stage of the impactor. The second dimension J indicates the impactor number (same as code variable MPACNO used to distinguish between impactors of the same type). The third dimension K indicates the type of impactor. The diameter of the jets at each stage in centimeters as specified in COMBK2 are in Tables 10, 11, 12, and 13. Note that even though there are only four Brink impactors, three University of Washington impactors, and one MRI impactor used, a dummy value of 0.0 is used for DC_{I52}, DC_{I62}, DC_{I43}, DC_{I53}, DC_{I63}, and DC_{I24}-DC_{I64} jet diameters, also for $DC_{82}K$, $DC_{83}K$, and $DC_{84}K$ (even though there are only 7 stages for the Brink, University of Washington, and MRI impactors). Again, the dummy value 0.0 is used in these positions to keep the proper ordering of this 8x6x4 array. The user should use his own measured jet diameters in this array.

Input to Program MPPROG

Card Input--

Card A--The type of impactor used to obtain data is indicated by coding on this card. Also, if physical density is input (card D, columns 18-21), this card contains the coding which indicates whether the definition according to the Task Group on Lung Dynamics[1] or Mercer's definition[2] of aerodynamic diameter is to be used on the second calculation of D_{50}'s cumulative mass loadings, etc., for a given run.

Column 1: Punch a "1" here if the Andersen Mark III Stack Sampler is used to obtain data. Punch "2" here if the modified Brink Cascade Impactor is used. Punch "3" here if the University of Washington Mark III Source Test Cascade Impactor is used. Punch "4" here if the Meteorology Research, Inc., Cascade Impactor is used.

TABLE 10. AVERAGE DIAMETER MEASURED FOR EACH STAGE OF SIX ANDERSEN IMPACTORS[a]

Impactor no.: Stage no.	I	229 DC_{I11}	231 DC_{I21}	583 DC_{I31}	619 DC_{I41}	620 DC_{I51}	627 DC_{I61}
0	1	0.1632	0.1632	0.1671	0.1621	0.1621	0.1651
1	2	0.1233	0.1253	0.1281	0.1263	0.1249	0.1240
2	3	0.0954	0.0949	0.0953	0.0946	0.0935	0.0951
3	4	0.0742	0.0749	0.0780	0.0757	0.0751	0.0774
4	5	0.0577	0.0569	0.0547	0.0581	0.0563	0.0565
5	6	0.0368	0.0369	0.0359	0.0355	0.0359	0.0346
6	7	0.0254	0.0254	0.0269	0.0258	0.0264	0.0266
7	8	0.0255	0.0257	0.0253	0.0245	0.0250	0.0245

---

a. A maximum of 6 impactors of this type can be used.

TABLE 11. MEASURED JET DIAMETER FOR EACH STAGE OF FOUR BRINK IMPACTORS[a]

Impactor no.: Stage no.	I	A DC_{I12}	B DC_{I22}	C DC_{I32}	D DC_{I42}	none DC_{I52}	none DC_{I62}
0	1	0.3554	0.3618	0.3658	0.3560	0.0000	0.0000
1	2	0.2422	0.2414	0.2460	0.2461	0.0000	0.0000
2	3	0.1779	0.1737	0.1724	0.1778	0.0000	0.0000
3	4	0.1364	0.1366	0.1360	0.1368	0.0000	0.0000
4	5	0.0884	0.0918	0.0896	0.0937	0.0000	0.0000
5	6	0.0705	0.0719	0.0719	0.0730	0.0000	0.0000
6	7	0.0556	0.0532	0.0589	0.0550	0.0000	0.0000
none	8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

---

[a] A maximum of 6 impactors of this type can be used.

TABLE 12. AVERAGE JET DIAMETER MEASURED FOR EACH STAGE OF FOUR UNIVERSITY OF WASHINGTON MARK III IMPACTORS[a]

Impactor no.: Stage no.	I	A DC_{I13}	B DC_{I23}	C DC_{I33}	D DC_{I43}	none DC_{I53}	none DC_{I63}
1	1	1.82372	1.82372	1.82372	1.82372	0.0000	0.0000
2	2	0.5768	0.5822	0.5874	0.5743	0.0000	0.0000
3	3	0.2501	0.2458	0.2459	0.2512	0.0000	0.0000
4	4	0.0808	0.0802	0.0807	0.0793	0.0000	0.0000
5	5	0.0524	0.0504	0.0532	0.0495	0.0000	0.0000
6	6	0.0333	0.0340	0.0376	0.0330	0.0000	0.0000
7	7	0.0245	0.0323	0.0260	0.0229	0.0000	0.0000
none	8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

---

a. A maximum of 6 impactors of this type can be used.

TABLE 13. AVERAGE JET DIAMETER MEASURED FOR EACH STAGE OF ONE METEOROLOGY RESEARCH INCORPORATED IMPACTOR[a]

Impactor no: Stage no.	I	A DC_{I14}	none DC_{I24}	none DC_{I34}	none DC_{I44}	none DC_{I54}	none DC_{I64}
1	1	0.870	0.0000	0.0000	0.0000	0.0000	0.0000
2	2	0.476	0.0000	0.0000	0.0000	0.0000	0.0000
3	3	0.205	0.0000	0.0000	0.0000	0.0000	0.0000
4	4	0.118	0.0000	0.0000	0.0000	0.0000	0.0000
5	5	0.084	0.0000	0.0000	0.0000	0.0000	0.0000
6	6	0.052	0.0000	0.0000	0.0000	0.0000	0.0000
7	7	0.052	0.0000	0.0000	0.0000	0.0000	0.0000
8	none	0.000	0.0000	0.0000	0.0000	0.0000	0.0000

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[a] A maximum of 6 impactors of this type can be used.

Column 2: Punch a "0" here or leave blank if the density (on card D, columns 18-21) is physical density and if the classic definition of aerodynamic diameter is to be used for the second calculation of D_{50}'s, i.e., Cunningham correction factor as function of cut point diameter in an iterative evaluation. Punch a "1" here if the density (on Card D, columns 18-21)is physical density and if Mercer's definition of aerodynamic diameter is to be used for the second calculation of D_{50}'s, i.e., Cunningham correction factor is 1 with no iteration. The value punched here is overridden if unit density is punched on card D, columns 18-21 (see below).

Card B--The general identification label is punched on this card. Everything punched on this card will appear on any line printer output and on any statistical graphs which pertain to averaged data for all impactor runs using this impactor. See mainline program STATIS. This label usually includes testing site, date, and run numbers included in this job. The card is read using 80A1 format. Therefore, any combination of letters, numbers, or symbols is acceptable.

Columns 1-80: Punch the general identification label.

Card C--Coding to indicate the number of the impactor used is punched on this card. This value together with the impactor type coding punched in the first column of Card A indicates the specific impactor. Impactor identification is given here for the impactors available at Southern Research Institute, and only serve as an example to the program user.

Column 2: If the Andersen impactor is used, the following listing shows the number punched for the indicated impactor used:

Punch	...if this Andersen impactor used
"1"	#229
"2"	#231
"3"	#583
"4"	#619
"5"	#620
"6"	#627

If the Brink impactor is used, the following listing shows the number punched for the indicated impactor used:

Punch	...if this Brink impactor used
"1"	A
"2"	B
"3"	C
"4"	D

If the University of Washington impactor is used, the following listing shows the number punched for the indicated impactor used:

Punch	...if this U. of W. impactor used
"1"	A
"2"	B
"3"	C
"4"	D

If the Meteorology Research, Inc., impactor is used, punch "1" in Column 1.

Card C is the first of 6 cards read for each input data set. The program will continue to read data sets until a card containing a nonpositive integer in Column 1 is read in this position. The reading of a new data set can, therefore, be stopped by placing a blank card in this card position. This is then the last data card.

Card D--This card contains the impactor pressure and temperature conditions, the stack temperature, the assumed particle density, the duration of sampling, maximum particle size, configuration constants (applicable if the Brink impactor is being used(, and coding to indicate whether the back-up filter is used.

Columns 1-5: Punch the gas pressure at the impactor inlet in inches of mercury using an F5.2 format.

Columns 6-11: Punch the temperature of the stack in degrees Fahrenheit using an F6.1 format.

Columns 12-17: Punch the temperature of the impactor in degrees Fahrenheit using an F6.1 format.

Columns 18-21: Punch the assumed density of the particle in grams per cubic centimeter to be used for the first calculation of D_{50}'s using an F4.2 format. If the assumed physical density (>1.0) is punched, it is used for the first calculation of D_{50}'s, and the second calculation of D_{50}'s is based on assumed unit density where the definition according to the Task Group on Lung Dynamics (TGLD)[1] or Mercer's definition[2] of aerodynamic diameter is used (dependent on coding punched on card A, column 2). If unit density is punched here, the TGLD definition of aerodynamic diameter is used for the first calculation of D_{50}'s; Mercer's definition of aerodynamic diameter is used for the second calculation of D_{50}'s regardless of value punched on card A, column 2.

Columns 22-26: Punch the duration of impactor sampling in minutes using an F5.1 format.

Columns 27-31: Punch the maximum particle diameter of material collected in micrometers using an F5.1 format.

Column 32: Punch a "1" here if the Brink impactor is used with cyclone. Otherwise punch "0" or leave blank.

Column 33: Punch a "1" here if the Brink impactor is used with stage 0. Otherwise punch "0" or leave blank.

Column 34: Punch the index of the last stage if the Brink impactor is used. This is either "5" or "6". If the Andersen impactor, University of Washington, or MRI impactor is used, punch "0" or leave blank.

Column 35: Punch a "1" here if the back-up filter is used in the impactor. Punch "0" here or leave blank if the filter is not used.

Card E--This card contains the fractional gas composition. The composing gases are carbon dioxide (dry), carbon momoxide (dry), nitrogen (dry), oxygen (dry), and water. All fractions are read using F6.2 format.

Columns 1-6: Punch the dry gas fraction of carbon dioxide.

Columns 7-12: Punch the dry gas fraction of carbon monoxide.

Columns 13-18: Punch the dry gas fraction of nitrogen.

Columns 19-24: Punch the dry gas fraction of oxygen.

Columns 25-30: Punch the fraction of water-steam.

Card F--This card contains the particulate masses captured at each stage of the cascade impactor. All masses are read using F6.2 format.

Columns 1-6: Punch the mass captured on the back-up filter in milligrams.

Columns 7-12: Punch the mass captured on the last (finest D_{50}) stage in milligrams.

Columns 13-18: Punch the mass captured on the next to the last stage in milligrams.

Continue this list using Columns 19-24, 25-30, etc., punching the masses captured on each stage in milligrams. Note that the order is by descending order of stage numbers so that the final number punched on the card is the mass captured on the first (coarsest) stage in milligrams or in the cyclone if the Brink impactor is used. If a stage weight is zero, the field allocated to that stage may be left blank or punched as "0".

Card G--This card contains the impactor sampling flow rate. The number is read using an F7.4 format.

Columns 1-7: Punch the impactor sampling flow rate in actual cubic feet per minute.

Card H--This card contains the individual run identification label. Everything punched on this card will appear verbatim at the top of line printer output pertaining to that run, and also above any graph plotted (see mainline program GRAPH) pertaining to this one run. This label usually includes the name of the testing site, whether inlet or outlet data, the run number, testing date, and location of testing port. The card is read using an 80A1 format. Therefore, any combination of letters, numbers, or symbols is acceptable.

Columns 1-80: Punch the individual run identification label.

Cards C through H are repeated for each new data set (i.e., for each run of the impactor). The final card (which would be in card position C of the next set of data, had there been more runs of the impactor to process) is left blank to end reading and processing of further data.

File Input--

There are no variable values input to program MPPROG by means of file reading.

Output from Program MPPROG

Line Printer Output--

Each impactor run data set will cause two output forms of the type discussed here. The first output for the given run is the result of calculations made with density of the particles taken as their physical density. Identical calculations are made with density of the particles taken as unit density = 1.0 gram/cubic centimeter (aerodynamic diameter). Of course, output values for the two differ where calculations are dependent on this density. Two choices are available for unit density calculations. D_{50} values can be calculated using the Task Group on Lung Dynamics definition (TLGD), or the aerodynamic impaction diameter definition of Mercer.

The individual identification label as input on Card B is printed at the top of the page.

Line 1: The individual run identification label.

The next five lines give information on running conditions, gas composition, and general characteristics of the particulate content.

Line 2:

a. Impactor flow rate in actual cubic feet per minute (as input)
b. Impactor temperature in degrees Fahrenheit (as input)
c. Impactor temperature in degrees centigrade
d. Sampling duration in minutes (as input)

Line 3:

a. Impactor pressure drop in inches of mercury
b Stack temperature in degrees Fahrenheit (as input)
c. Stack temperature in degrees centigrade

Line 4:

a. Particle density in grams per cubic centimeter. This is as input for the first calculations of D_{50}'s cumulative mass loadings, etc. This is 1.0 gram/cubic centimeter for the second calculation of these same values.

b. Stack pressure (pressure at impactor inlet) in inches of mercury (as input)

c. Maximum particle diameter in micrometers (as input)

Line 5:

a. Wet percent gas content of carbon dioxide

b. Wet percent gas content of carbon monoxide

c. Wet percent gas content of nitrogen

d. Wet percent gas content of oxygen

e. Percent gas content of water

Line 6:

a. Calculated total mass loading in grains per actual cubic foot

b. Calculated total mass loading in grains per dry normal cubic foot.

c. Calculated total mass loading in milligrams per actual cubic meter.

d. Calculated total mass loading in milligrams per dry normal cubic meter

The remainder of line printer output shows the particle concentration and distribution according to particle size in the form of a chart.

Line 7: "IMPACTOR STAGE" followed by the column headings for each stage, e.g., "S1", "S2", "S3", "S4", "S5", "S6", "S7", "S8", and "FILTER" for the Andersen impactor.

Line 8: "STAGE INDEX NUMBER" followed by the column headings, *e.g.*, "1", "2", "3", "4", "5", "6", "7", "8", and "9" for the Andersen impactor. The last number is the stage index number for the back-up filter. Each of the index numbers is aligned with its proper "IMPACTOR STAGE" column heading. There are NMASS such "IMPACTOR STAGE" and "STAGE INDEX NUMBER" column headings.

Line 9: "D50" (MICROMETERS)" is followed by the particle diameter lower size limit for each stage in micrometers. There is no such "lower limit" given for the all-capturing back-up filter, and, therefore, there are only NMASS-1 diameter sizes listed here.

Line 10: "MASS (MILLIGRAMS)" is followed by the mass captured at each stage in milligrams as input. There are NMASS values listed here.

Line 11: "MG/DNM3/STAGE" is followed by the equivalent mass loading at each stage in milligrams per dry normal cubic meter. There are NMASS values listed here.

Line 12: "CUM. PERCENT OF MASS SMALLER THAN D50" is followed by this cumulative percent value at each stage. There are only NMASS-1 percent values listed here, since there is no lower size limit for the back-up filter and no mass loading which escapes this filter.

Line 13: "CUM. (MG/ACM) SMALLER THAN D50" is followed by the cumulative particulate mass loading with diameters less than the lower size limit of the given stage. The units here are milligrams per actual cubic meter. There are only NMASS-2 values since there is no mass loading which escapes the back-up filter.

Line 14: "CUM. (MG/DNCM) SMALLER THAN D50" as described above but in units of milligrams per dry normal cubic meter.

Line 15: "CUM. (GR/ACF) SMALLER THAN D50" as described above but in units of grains per actual cubic foot.

Line 16: "CUM. (GR/DNCF) SMALLER THAN D50" as described above but in units of grains per dry normal cubic foot.

Line 17: "GEO. MEAN DIAMETER" is followed by the geometric mean diameter in micrometers of all particles which may be captured at each stage obtained by taking the mid-point diameter of the natural log difference of the D_{50} of the given stage and the D_{50} of the previous stage.

Line 18: "DM/DLOGD (MG/DNCM)" is followed by the change in mass concentration at each stage in milligrams per dry normal cubic meter. These are also known as the values of the size distribution on a mass basis. There are NMASS values.

Line 19: "DN/DLOGD (NO. PARTICLES/DNCM)" is followed by the change in number concentration at each stage in number of particles per dry normal cubic meter. These are also known as the values of the size distribution on a number basis. There are NMASS dN/dlogD values.

Line 20: A footnote is given here for the definition of "normal conditions" by engineering standards. It states, "NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760 MM HG."

Line 21: A footnote is given here if the figures on this output page have been made for assumed aerodynamic diameter, density = 1.0 gram/cubic centimeter. The definition used for aerodynamic diameter is specified by writing either "AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO THE TASK GROUP ON LUNG DYNAMICS" or "AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO MERCER".

Graph Output--

There are no graphs plotted by program MPPROG

File Output--

There is one random access file used for output in the program MPPROG. It is referenced as "FILNAM" under the file name "KMC 001". The file is referred to as file number 10 (decimally) in all written statements for this file. File 10 has 101 records each with 251 words. For each run of the impactor, 2 records are used to store compiled data. If the first or odd numbered record stores data compiled while assuming a physical density, the second or even numbered record stores data compiled while assuming unit density of 1.0 gram per cubic centimeter, using either the TGDL or Mercer's definition of aerodynamic diameter. If the first or odd numbered records store data compiled while assuming unit density, the TGLD definition of aerodynamic diameter is used to get these values. In this case, the second or even numbered records also store data compiled while assuming unit density, but Mercer's definition of aerodynamic diameter is used. The last record, record 101, is used to store general information which applies to all impactor runs.

For records 1-100, below is listed the variable names, their dimension and total number of words (integer variable values requiring one word, real variable values two words) and a description of the variable. These records contain information referring to an individual impactor run.

IS: This is a one-dimensional integer requiring one word. It is the record index number.

NFIT: This is a one-dimensional integer requiring one word. It is the total number of points which may be used in making the cumulative mass loading curve fit in program SPLIN1. This number of points comes from taking the nonzero values for cumulative mass loading of particulate less than the D_{50} of the given stage vs. the stage D_{50} plus one point for the total grain loading vs. the maximum particle diameter.

GRNAM: This is a one-dimensional real variable requiring two words. It is the value of the total mass loading in milligrams per actual cubic meter.

ID: This is a one-dimensional integer variable array with 80 elements requiring 80 words. It is the individual run identification label giving such information as name of testing site, whether it is inlet or outlet data, the run number (not the same as IS), testing data, and location of testing port.

RHO: This is a one-dimensional real variable requiring two words. It is the value of the assumed density. This is the physical density if IS is odd or unit density if IS is even. The density is given in grams per cubic centimeter.

TKS: This is a one-dimensional real variable requiring two words. It is the temperature of the stack in degrees Kelvin.

POA: This is a one-dimensional real variable requiring two words. It is the pressure at the impactor inlet in atmospheres.

FG_5: This is one value of a five element, one-dimensional real variable array. This one value requires two words. It is the percent water content of the flue gas.

DSMA: This is a one-dimensional real variable requiring two words. It is the smallest stage D_{50} value in micrometers, *i.e.*, the D_{50} of the last (finest) stage.

DMAX: This is a one-dimensional real variable requiring two words. It is the diameter in micrometers of the largest particle captured.

DPC: This is a one-dimensional real variable array with 8 elements requiring 16 words. These are the D_{50} values or lower size limit values in micrometers for the stages of the impactor.

CUMG: This is a one-dimensional real variable array with 8 elements requiring 16 words. These are the cumulative particulate mass loading values with diameters less than the lower size limit of the given stage in milligrams per actual cubic meter.

DMDLD: This is a one-dimensional real variable array with 9 elements requiring 18 words. These are the values at each stage (including the back-up filter) of the size distribution on a mass basis in milligrams per dry normal cubic meter. These values are also referred to as the change in mass concentration at each stage.

GEOMD: This is a one-dimensional real variable array with 9 elements requiring 18 words. These values are the geometric mean diameter of all particles at each stage (including the back-up filter) in micrometers.

DNDLD: This is a one-dimensional real variable array with 9 elements requiring 18 words. These are the values at each stage (including back-up filter of the size distribution on a number basis in number of particles per dry normal cubic meter. These values are also referred to as the change in number concentration at each stage.

CYC3: This is a one-dimensional real variable requiring two words. It is the lower size limit of the cyclone in micrometers. The value written here is 0.0 unless the Brink impactor is used with the cyclone.

MC3: This is a one-dimensional integer variable requiring one word. It is the code variable to indicate use of the cyclone with the Brink impactor. If the cyclone is used with the Brink impactor, 1 is entered here. Otherwise, the MC3 value is entered as 0.

MOO: This is a one-dimensional integer variable requiring one word. It is the code variable to indicate use of stage 0 with the Brink impactor. If this stage 0 is used with the Brink impactor, 1 is entered here. Otherwise, the M00 value is entered as 0.

MS: This is a one-dimensional integer variable requiring one word. It is the code variable to indicate the last stage of the Brink impactor. The figure entered here is then 5 or 6 depending on the configuration used for the Brink impactor. If the Andersen, University of Washington, or MRI impactor is used, 0 is entered here as the value of MS.

JV: This is a one-dimensional integer variable requiring one word. It is the number of stage D_{50} values. If the Brink impactor is used, one is added for the cyclone (whether it is used or not).

$XNDPEN_I$, I=1, NFIT: This is a one-dimensional real variable array with NFIT elements requiring (2xNFIT) words. These are the values of the independent variable used for fitting in program SPLIN1. These are the D_{50} values of each stage of the impactor and the maximum captured particle diameter in micrometers (excluding the D_{50} of stage 2 if the Andersen impactor is used).

YO_I, I=1, NFIT: This is a one-dimensional real variable array with NFIT elements requiring (2xNFIT) words. These are the values of the dependent variable used for fitting in program SPLIN1. These are the nonzero cumulative mass loading values less than the stage D_{50} and the total mass loading in milligrams per actual cubic meter (excluding the mass loading less than D_{50} of stage 2, if the Andersen, University of Washington, or MRI impactor is used).

PROGRAM SPLIN1

Program SPLIN1 uses a series of overlapping, second degree polynomials to fit each specified set of $\log_{10}$ (cumulative mass loading) vs. $\log_{10}(D_{50})$ values such that both the polynomials and their first derivatives are continuous at the points of overlap. It is executed as the second program in the cascade impactor data reduction system. Impactor program MPPROG must first be executed in order to store values to be used for fitting on the random access file KMC001 (file 10). These stored values are the set of cumulative mass loadings and total mass loading YOI, I =1, NFIT, in milligrams per actual cubic meter and the set of stage diameter cut points and maximum particle diameter, XNDPEN (I), I = 1, NFIT, in micrometers.

After fits are made, the following information is stored for each data set in file FILSPL (file 11) for use in all subsequent programs of the system:

NPT - the number of points used in making the fit (X_I,Y_I), I = 1, NPT - **the boundary point values** for each of these intervals. These include $\log_{10}$ $(XNDPEN_I,YO_I)$, I = 1, NFIT in addition to interpolated points. $COE_{I,J}$, I = 1, INT, J = 1, 3 - the spline curve fit second degree polynomial coefficients for each interval. Here INT = number of intervals = NPT -1.

Breakdown of Program SPLIN1

028-029: Record 101 contains general information pertaining to all runs. There are two records for each run. ISFIN is the last record containing individual run data in file 10.

034: The code variable KREAD is read to specify whether all sets of data are to be fitted (KREAD = 0) or whether only certain specified sets are to be fitted (KREAD = 1).

041-044: Each pair of $\log_{10}(D_{50})$ values has its range divided into equal subintervals (N = 4). R is the real number equivalent, 4.0. The interval between $\log_{10}(D_{50})$ of the largest D_{50} stage and the $\log_{10}$ (maximum particle diameter) is divided into NN equal subintervals (NN = 8). RR is the real number equivalent, 8.0.

045: The loop begins here which on each pass reads a set of cumulative mass loadings plus total mass loading, YO_I, I = 1, NFIT, and the corresponding set of D_{50} values plus maximum particle diameter, $XNDPEN_I$, I = 1, NFIT. A new set of points (X,Y) are defined based on the set of points, $\log_{10}$ (XNDPEN, YO), and points interpolated in between. A series of overlapping, second degree polynomials are fitted to these values such that the polynomials and their first derivatives are continuous for each contiguous set of data points. The number of points NPT used to made the fits, the point values $(X, Y)_I$, I = 1, NPT (which are the inverval boundary points), and the second degree polynomial curve fit coefficients for the intervals, COE_{IJ}; I = 1, INT and J = 1, INT where INT = NPT -1, are stored on a record of file FILSPL (file 11). Each traverse of the loop produces a polynomial fit to a new set of cumulative mass loading vs. D_{50} values and stores the results.

046-065: A record of file KMC001 (file 10) is read here to obtain the following:

NFIT = the number of cumulative mass loading vs. D_{50} points (+1 for total mass loading vs. maximum particle diameter). This is less than the number of stages +1 if a cumulative mass loading is to be ignored as for stage 2 of the Andersen, University of Washington, or MRI impactors.

$XNDPEN_I$, I = 1, NFIT - the set of D_{50} values and maximum particle diameter (with possible exclusions as noted above).

YO_I, I = 1, NFIT - the set of cumulative mass loading values and total mass loading (with possible exclusions as noted above).

The other variables read from the record are not used. The number of the record read, IAV, is the same as the loop index, INDEX, if all sets of data are to be fitted (KREAD = 0). If only specified sets are to be fitted, (KREAD $\neq$ 0), the specific record number to be read, IAV, is read by card input. A blank card stops the program for KREAD $\neq$ 0.

066-074: Some constants used in the loop to follow are defined here. NFIT is the number of original points to be fitted.

$$NFIT1 = NFIT - 1 \tag{74}$$

$$NFIT2 = NFIT - 2 \tag{75}$$

NPT = total number of points used for fitting between (and including) the D_{50} of the last stage and maximum particle diameter = (NFIT2 x 4) + 9 (76)

075-105: The loop begins here which defines the set of points to be fitted from $\log_{10}(D_{50})$ of the last stage to $\log_{10}(D_{50})$ of the first stage plus two more extrapolated points beyond $\log_{10}(D_{50})$ of the first stage. These are the (X1,Y1) points or (X,Y) points. The two sets are equivalenced to each other. On each traverse of this loop, four more points are defined, except when I = NFIT2, when seven more points are defined. The first of these, $(X1_M, Y1_M)$, is a function of cumulative mass loading vs. D_{50}:

$$X1_M = \log (XNDPEN_I) \qquad (77)$$

$$Y1_M = \log (YO_I) \qquad (78)$$

where M = (I-1) x 4 + 1, i.e., M increases by 4 on each traverse so that:

$$(X1,Y1)_1 = \log_{10} (XNDPEN_1, YO_1)$$

$$(X1,Y1)_5 = \log_{10} (XNDPEN_2\ YO_2)$$

$$(X1,Y1)_9 = \log_{10} (XNDPEN_3, YO_3)$$

. . .

. . .

$$(X1,Y1)_{MM} = \log_{10} (XNDPEN,YO)_{NFIT2}$$

where MM = (NFIT2-1) x 4 + 1

We will occasionally adopt the convention of writing $\log_{10} (XNDPEN_I YO_I)$ as $\log_{10} (XNDPEN,YO)_I$ for ease of presentation. Thus:

$$(X1,Y1)_1 = \log_{10} (XNDPEN,YO)_1$$

$$(X1,Y1)_5 = \log_{10} (XNDPEN,YO)_2$$

$$(X1,Y1)_9 = \log_{10} (XNDPEN,YO)_3$$

. . .

. . .

$$(X1,Y1)_{MM} = \log_{10} (XNDPEN,YO)_{NFIT2}$$

The additional number of (X1,Y1) points to be defined in traversing the "DO 100" loop is JJ = 3. These points are equally spaced on a common log scale between $\log_{10} (XNDPEN)_I$ and $\log_{10} (XNDPEN)_{I+1}$. On the last traverse where I = NFIT2, six more points are defined since JJ = 6. The first three are equally spaced on a common log scale as before. The fourth = $\log_{10}$ (XNDPEN,

$YO)_{NFIT1}$ where NFIT1 = NFIT - 1. The last two points are extrapolated beyond $\log_{10}$ (XNDPEN, $YO)_{NFIT1}$ and are spaced by the same $\log_{10}$ increment as the previous four points. This $\log_{10}$ increment between points, XINC, is defined as:

$$XINC = [\log_{10}(XNDPEN)_{I+1} - \log_{10}(XNDPEN)_{I}]/4. \quad (79)$$

The range is divided by 4 here so that the $\log_{10}$ interval of each pair of cumulative mass loading vs. D_{50} points is divided into 4 equal subintervals with 3 interval boundary points to be interpolated.

106-134: The "DO 1100" loop here prepares the input for subroutine SIMQ (A, B, 3, KS). SIMQ is one of the IBM 360 Scientific Subroutine Package-Version III programs. SIMQ solves three simultaneous equations here to fit a second degree polynomial to the following points:

$$\log_{10} (XNDPEN,YO)_{I} \quad (80)$$

$$\log_{10} (XNDPEN,YO)_{I+1} \quad (81)$$

$$\log_{10} (XNDPEN,YO)_{I+2} \quad (82)$$

If

$$SLOPE = B_2 + 2B_3[\log_{10}(XNDPEN)_{I}] < 0, \quad (83)$$

or if

$$SLOPE = B_2 + 2B_3[\log_{10}(XNDPEN)_{I+1}] < 0, \quad (84)$$

the original second degree polynomial coefficients vector $\overline{B}$ found by SIMQ is replaced with the coefficients defining a straight line fit between $\log_{10}(XNDPEN,YO)_{I}$ and $\log_{10}(XNDPEN,YO)_{I+1}$:

$$B_1 = \log_{10}(YO)_{I} - B_2\log_{10}(XNDPEN)_{I} \quad (85)$$

$$B_2 = \log_{10}(YO_{I+1}/YO_{I})/\log_{10}(XNDPEN_{I+1}/XNDPEN_{I}) \quad (86)$$

$$B_3 = 0.0 \quad (87)$$

135-139: The three interpolated points between $\log_{10}$ $(XNDPEN,YO)_{I}$ and $\log_{10}$ $(XNDPEN,YO_{I+1})$ (or six points if I = NFIT2) are defined here using the appropriate fitting coefficients as described at cards 106-134:

$$X1_K = \log_{10}(XNDPEN_I) + (J)\ (XINC) \tag{88}$$

$$Y1_K = B_2\ X1_K + B_3(X1_K)^2 \tag{89}$$

Here K = M + J. M is the index of the (X1,Y1) point which is the same as $\log_{10}(XNDPEN,YO)_I$, i.e. M = (I-1) x 4 + 1 (see discussion of cards 075-105). J is the index of this small nested "DO 100" loop which defines the three (six if I = NFIT2) interpolated points.

At this location in the program, all (X1, Y1) points to be used for curve fitting over the range of the D_{50}'s have been defined. Any curve fitting up to this point has been only for the purpose of defining the (X1, Y1) points to be used for the actual final fitting of $\log_{10}$ (cumulative mass loading) vs. $\log_{10}$ (D_{50}) in the section to follow. Note that (X1, Y1) points have not been defined over the range of $\log_{10}(D_{50})$ of the first stage, = $\log_{10}(XNDPEN)_{NFIT1}$ to $\log_{10}$ (maximum particle diameter) = $\log_{10}(XNDPEN)_{NFIT}$) except for two extrapolated points beyond $\log_{10}(XNDPEN)_{NFIT1}$, which will be replaced. The interpolated (X1, Y1) points for this last range are to be defined by a hyperbolic fit to $\log_{10}(XNDPEN,YO)_{NFIT1}$ and $\log_{10}(XNDPEN,YO)_{NFIT}$ as opposed to the parabolic fit used previously. Also, the (X1,Y1) points used previously are now referred to as (X, Y) points. These two sets are made the same by the equivalence statement at card 018 as are the curve fitting coefficients COE and COE1.

140-154: The first three (X,Y) points, (X_1,Y_1), (X_2,Y_2), and (X_3,Y_3), are fitted here with a second degree polynomial in order to define the slope at (X_1,Y_1). As above we will occasionally adopt the convention of writing (X_1,Y_1) as $(X,Y)_1$, etc., for ease of presentation. The coefficients found here do not define the final curve fit over the first interval but are used only to define the slope at $(X,Y)_1 = \log_{10}(XNDPEN,YO)_1$. The matrix equation $\overline{AX} = \overline{B}$ must be solved for $\overline{X}$. The coefficient matrix $\overline{A}$ is defined as:

$$\begin{pmatrix} A_1 & A_4 & A_7 \\ A_2 & A_5 & A_8 \\ A_3 & A_6 & A_9 \end{pmatrix} = \begin{pmatrix} 1 & X_1 & (X_1)^2 \\ 1 & X_2 & (X_2)^2 \\ 1 & X_3 & (X_3)^2 \end{pmatrix} \qquad (90)$$

The constant vector $\overline{B}$ is defined as:

$$\begin{pmatrix} B_1 \\ B_2 \\ B_3 \end{pmatrix} = \begin{pmatrix} Y_1 \\ Y_2 \\ Y_3 \end{pmatrix} \qquad (91)$$

Subroutine SIMQ replaces vector $\overline{B}$ with the solution vector $\overline{X}$. Vector $\overline{B}$ now holds the coefficients for the second degree polynomial fit to points $(X,Y)_1$, $(X,Y)_2$, and $(X,Y)_3$.

155-179: The slope, SLOPE, at $(X,Y)_1$ is calculated here:

$$SLOPE = B_2 + 2B_3X_1 \qquad (92)$$

If SLOPE < 0.0, the polynomial curve fit through $(X,Y)_1$ must be redefined to assure a positive first derivative at this point. This is done by defining a point (X_0,Y_1) where $X_0 = X_1-(X_2-X_1)$ and making a second degree polynomial curve fit through (X_0,Y_1), (X_1,Y_1) and (X_2,Y_2). Since (X_0,Y_1) and (X_1,Y_1) have the same ordinate value and $Y_2>Y_1$, the only minimum of the second degree polynomial must lie between X_0 and X_1. The slope at (X_1,Y_1) is then positive. To find the fitting coefficients, the subroutine SIMQ (A, B, 3, KS) solves the matrix equation $\overline{AX} = \overline{B}$ for $\overline{X}$ where $\overline{A}$ is:

$$\begin{pmatrix} A_1 & A_4 & A_7 \\ A_2 & A_5 & A_8 \\ A_3 & A_6 & A_9 \end{pmatrix} = \begin{pmatrix} 1 & [X_1-(X_2-X_1)] & [X_1-(X_2-X_1)]^2 \\ 1 & X & (X_1)^2 \\ & X & (X_2)^2 \end{pmatrix} \quad (93)$$

and $\overline{B}$ is:

$$\begin{pmatrix} B_1 \\ B_2 \\ B_3 \end{pmatrix} = \begin{pmatrix} Y_1 \\ Y_1 \\ Y_2 \end{pmatrix} \quad (94)$$

The input vector $\overline{B}$ is destroyed in the computations of subroutine SIMQ. The solution fitting coefficients $\overline{X}$ are returned in place of $\overline{B}$.

180-181: The coefficients of the second degree polynomial which fits through point $(X,Y)_1$ with non-negative first derivative are saved as the fitting coefficients of the first interval between $(X,Y)_1$ and $(X,Y)_2$ as COE (1,I), I = 1, 3. These are only the temporary coefficients to find the first derivative at $(X,Y)_1$ in order to make the final fit over the first interval in the first traverse of the "DO 50" loop beginning at statement 23 (card 204).

182-189: The beginning and ending index values are defined here for the loop which makes the final fits over the intervals between $\log_{10}(\text{XNDPEN,YO})_1$ and $\log_{10}(\text{XNDPEN,YO})_{\text{NFIT1}}$. The first interval, II, is 1. The lower boundary point of this interval is $(X,Y)_1 = \log_{10}(\text{XNDPEN,YO})_1$. The last interval, INTS1, is NPT-9 = NFIT2 x 4. This interval has an upper boundary $(X,Y)_{(\text{NFIT2x4})+1} = \log_{10}(\text{XNDPEN,YO})_{\text{NFIT1}}$.

190-235: This "DO 50" loop makes second degree polynomial fits to all intervals between $\log_{10}(\text{XNDPEN,YO})_1$ and $\log_{10}(\text{XNDPEN,YO})_{\text{NFIT}}$. These intervals are defined by the boundary points (X,Y) which also serve as the points to be fitted. The three equations used to define the fitting polynomial over a given interval I, between $(X,Y)_I$ and $(X,Y)_{I+1}$, must meet the following three conditions:

1. The fitting polynomial over interval I must have a continuous first derivative with that of intervals I-1. (For I = 1, the first derivative must be as found at cards 140-181).
2. The polynomial to be calculated for interval I must be continuous with the polynomial fitting interval I-1. (For I = 1, the polynomial must fit exactly through $(X,Y)_1$).
3. The fitting polynomial of this Ith interval which fits between points $(X,Y)_I$ and $(X,Y)_{I+1}$ goes through the (I+3)rd point. This means that a point beyond the fitted interval I is used to determine the fit over I. This has the effect of "looking ahead" at the coming points to influence the curve direction as one would do visually when using a French curve.

Mathematically, the above conditions may be expressed in order by the following equations:

1. $$COE_{I,2} + 2COE_{I,3}\, X_I = COE_{I-1,2} + 2COE_{I-1,3}\, X_I \tag{95}$$

2. $$COE_{I,1} + COE_{I,2}\, X_I + COE_{I,3}\, X_I^2 = COE_{I-1,1} + COE_{I-1,2}\, X_I + COE_{I-1,3}\, X_I^2 \tag{96}$$

3. $$COE_{I,1} + COE_{I,2}\, X_{I+3} + COE_{I,3}\, X^2_{I+3} = Y_{I+3} \qquad (97)$$

Here $COE_{I,J}$, J = 1,3 are the second degree polynomial curve fit coefficients to be determined for the Ith interval and $COE_{I-1,J}$, J=1,3 are similar coefficients found to fit over the previous interval. X_I is the ordinate of the lower boundary point of this Ith interval, and $(X,Y)_{I+3}$ is the point external to the actual fitted interval which is 3 points beyond the lower boundary of the Ith interval. To find the fitting coefficients $COE_{I,J}$, J=1,3 the matrix equation $\overline{AX} = \overline{B}$ is solved in the IBM 360 Scientific Subroutine, SIMQ (A, B, 3, K). The vector $\overline{A}$ is input as:

$$\begin{pmatrix} A_1 & A_4 & A_7 \\ A_2 & A_5 & A_8 \\ A_3 & A_6 & A_9 \end{pmatrix} = \begin{pmatrix} 0 & 1 & 2X_I \\ 1 & X_I & X_I^2 \\ 1 & X_{I+3} & X^2_{I+3} \end{pmatrix} \qquad (98)$$

The vector $\overline{B}$ is input as:

$$\begin{pmatrix} B_1 \\ B_2 \\ B_3 \end{pmatrix} = \begin{pmatrix} COE_{I-1,2} + 2COE_{I-1,3}\, X_I \\ COE_{I-1,1} + COE_{I-1,2}\, X_I + COE_{I-1,3} X_I^2 \\ Y_{I+3} \end{pmatrix} \qquad (99)$$

The solution vector $\overline{X}$ found by SIMQ is then returned with the fitting coefficient values. The values of vector $\overline{B}$ are destroyed in the computation and the solution coefficients of vector $\overline{X}$ are returned as $\overline{B}$. Thus the values of vector $\overline{B}$ are saved in the "DO 45" loop at card 233 upon return from SIMQ as the vector $COE_{I,J}$, J=1,3 for the fitting coefficients of interval I.

This "DO 50" loop is executed twice. The first execution fits second degree polynomials to the intervals between $\log_{10}(\text{XNDPEN,YO})_1$ and $\log_{10}(\text{XNDPEN,YO})_{\text{NFIT1}}$. The interval boundary points (X,Y) over the second range are calculated according to a hyperbolic fit between $\log_{10}$ $(\text{XNDPEN,YO})_{\text{NFIT1}}$ and $\log_{10}(\text{XNDPEN,YO})_{\text{NFIT}}$. The program then returns to statement 23 (card 204) for the second execution of the "DO 50" loop to make curve fits over these last intervals. (See discussion of cards 236-263.)

236-263: The boundary points of the last intervals for which fitting coefficients are to be defined are found here. These boundary points and their intervals cover the range of $\log_{10}(\text{XNDPFN,YO})_{\text{NFIT1}}$ to $\log_{10}(\text{XNDPEN,YO})_{\text{NFIT}}$, i.e., from $\log_{10}(D_{50})$ of the first stage to the $\log_{10}$(maximum particle diameter), plus two extrapolated points beyond $\log_{10}$(maximum particle diameter). The interval boundary points over this range are defined according to a hyperbolic fit to $(\text{XNDPEN},\log_{10}\text{YO})_{\text{NFIT1}}$ and $(\text{XNDPEN},\log_{10}\text{YO})_{\text{NFIT}}$:

$$\log Y = B_1 + B_2/X \qquad (100)$$

Note that the interval between these two points is divided into 8 subintervals with (X,Y) boundary points (rather than 4 subintervals as between each pair of D_{50}'s) with 2 more extrapolated (X,Y) points.

264-272: The index of the "DO 50" loop is the interval number. Here the beginning and ending indices, II and INTS1, respectively, are redefined for this loop. These values are:

II = NPT - NN

INTS1 = NPT-1

where NPT = total number of points between $\log_{10}$ (D_{50}) of the last stage to $\log_{10}$(maximum particle diameter), and NN = number of intervals defined between $\log_{10}(D_{50})$ of the first stage and $\log_{10}$ (maximum particle diameter). The program then returns to the "DO 50" loop at statement 23 (card 204) to make continuous second degree polynomial fits over this hyperbolic region just as is done over the range of the D_{50}'s.

273-284: The program comes to statement 55 (card 277) after curve fit coefficients for all intervals between $\log_{10}(D_{50})$ of the last stage to $\log_{10}$ (maximum particle diameter), inclusive, have been found. The total number of fitted intervals INT is now:

INT = NPT-1

where NPT is as defined above. The number of fitted points, NPT, the values of these points, which form the interval boundaries, $(X,Y)_I$ = 1, NPT, and the second degree polynomial curve fit coefficients for these intervals $COE_{I,J}$; I = 1, INT; J = 1, 3 are written on a record in the file FILSPL, (file 11). The record number used here, IAV, is the same as that in file KMC001, (file 10). There the original cumulative mass loading and total mass loading, YO_I, I = 1, NFIT, are recorded along with the original stage D_{50}'s and maximum particle diameter, $XNDPEN_I$, I = 1, NFIT. In all programs executed following SPLIN1 (*i.e.*, GRAPH, STATIS, and PENTRA), these interval boundary points and their curve fit coefficients are used to reproduce the cumulative mass loading vs. D_{50} curve fit and to derive the mass and number size distributions.

The program SPLIN1 now returns to the beginning of the "DO 400" loop to read the next set of cumulative mass loading (and total mass loading) vs. D_{50}'s (and maximum particle diameter) to be fitted, $(\text{XNDPEN,YO})_I$, I = 1, NFIT.

Subroutines Called by Program SPLIN1

Subroutine SIMQ (A, B, N, KS)--

This subroutine, the only subroutine called by SPLIN1, is taken directly from the IBM 360 Scientific Subroutine Package-Version III. It solves N simultaneous linear equations, $\overline{AX} = \overline{B}$ where $\overline{A}$ is the matrix of coefficients, $\overline{B}$ is the vector or original constants, and $\overline{X}$ is the solution vector. The input values of vector $\overline{B}$ are destroyed in the computation and the solution values of vector $\overline{X}$ are returned in its place.

Input to Program SPLIN1

Card Input--

Card A--This card contains the integer code KREAD which determines whether all records of file KMC001 (file 10) are to be read and cumulative mass loading vs. D_{50} values to be fitted, or whether only data from selected records are to be fitted.

Columns 1-2: The integer is read here in an I2 format. Punch a non-positive integer here (e.g., 0 is punched in column 2 or left blank) if all records of file 10 containing data are to be read, and fits are made to the set of cumulative mass loading (and total mass loading) vs. D_{50} (and maximum particle diameter) values found at each record. In this case Card A is the only card of the data deck. Punch a positive integer here (e.g., 1 is punched in column 1) if data from specified records is to be fitted. In this latter case, card set B follows.

Card Set B--Each of these cards has the record number of file KMC001 (file 10) containing cumulative mass distribution values to be fitted. These cards are included only if card A is punched with a positive number.

Columns 1-2: Punch the record number of the cumulative mass loadings (and total mass loading) vs. D_{50}'s (and maximum particle diameter) to be fitted. This is an I2 format.

There are as many cards in this card set B as there are sets of cumulative mass distributions to be fitted plus one additional card to stop the program. The last card of this set should be left blank (or 0 punched in columns 1 and 2) for this purpose.

File Input--

File 10--This is a random access file with the name KMC001. It contains 101 records of 251 words each. The variables of file 10 which are used in program SPLIN1 from records 1-100 are named and described below. The last record, record 101, is used to store general information which applies to all impactor runs. See PROGRAM MPPROG - File Output for the variables which make up each record of file 10.

Output from Program SPLIN1

Line Printer Output--

None

Graph Output--

None

File Output--

File 11--This is a random access file with the name FILSPL. It contains 100 records of 507 words each. The following variables make up each record of file 11:

NPT: This is an integer variable requiring one word. It is the total number of points which are fitted between $\log_{10}$(XNDPEN,YO), and $\log_{10}(\text{XNDPEN},\text{YO})_{\text{NFIT1}}$ inclusive, i.e., between $\log_{10}$(D_{50} of last stage, cumulative mass loading of last stage) and $\log_{10}$ (maximum particle diameter, total mass loading).

X: This is a real variable array with NPT values requiring 2 x NPT words. It is the set of abcissa values to which SPLIN1 makes its series of continuous second degree polynomial fits.

Y: This is a real variable array with NPT values requiring 2 x NPT words. It is the set of ordinate values to which SPLIN1 makes its series of continuous second degree polynomial fits.

COE: This is a two dimensional array with INT values in the first dimension and three values in the second dimension. COE thus requires 2 x INT x 3 words. Recall that INT, the number of intervals, equals NPT-1. This is the set of curve fitting coefficients for the cumulative mass distribution. The first index refers to the order of the coefficient. The second index refers to the order of the coefficient. For example, COE (14,J), J = 1,3 is the set of second degree polynomial coefficients fitting the 14th interval such that:

$$Y = COE(14,1) + COE(14,2)\ X + COE(14,3)X^2$$

where $X_{14} < X < X_{15}$

PROGRAM GRAPH

Program GRAPH is the third program of the Cascade Impactor Data Reduction System. Its execution follows that of impactor program MPPROG and cumulative mass curve fitting program SPLIN1. The purpose of GRAPH is to make all graphs desired for the individual runs of the impactors. For each type of graph there are two graphs possible - one for particle sizing data obtained by assuming unit density and one for data obtained by assuming physical density. These types of graphs include cumulative mass loading less than the stage D_{50} vs. stage D_{50}, and both dM/dlogD and dN/dlogD size distribution plots vs. the geometric mean diameter of the stages. There are also similar plots which show the above "raw data" points plotted (finite differences data based on the mass captured at each stage as generated by MPPROG), with "fitted data" (interpolation data as generated by SPLIN1) superimposed. A fitted curve may be superimposed on the cumulative mass loading graph, and a dM/dlogD or dN/dlogD size distribution based on the derivative of fitted cumulative mass loading curve may be superimposed on the original size distribution plot.

GRAPH is the only program of this data reduction system which may be omitted from the execution series since it adds no values to the random access files KMC001 or FILSPL(used in subsequent programs). GRAPH reads these files in order to label and plot graphs. One other file is used internally. This is the random access file named GRAPH0 used to store plotting code values read in from the card reader for each run of the impactor. The file GRAPH0 then contains instructions to plot or suppress any given individual run graph. This file is used in no program other than GRAPH. Therefore, if one is interested only in averaged data and penetration-efficiency results, this program is not executed.

It should be noted that in the Breakdown of Program GRAPH below, physical density is assumed to have been input to program MPPROG. This results in calculations based on physical density and unit density (definition of aerodynamic diameter user specified) being listed alternately in output files. The user may instead desire to input only unit density to MPPROG yeilding calculations based on the two different definitions of aerodynamic diameter (Mercer's[2] and Task Group on Lung Dynamics[1]).

Breakdown of Program GRAPH

029-045: Read the identification and general plotting input data from file 10.

046-063: Read coding from cards to indicate how range and number of cycles for graphs is to be determined. Also, read coding to control read-in of coding which specifies desired plots.

064-106: Read the individual run plotting codes from cards in the manner indicated from above input, and write these values on file 8.

107-111: The first graphs drawn will be based directly upon the masses captured at each stage (along with other factors such as flow rate, temperature, etc.) rather than on points calculated from a curve fit. These are sometimes referred to as the "raw data" graphs. The code value ISIG is set equal to 0 here in order to produce these graphs.

112-119: The remainder of the program is a large loop beginning here at card 119. It is controlled by the variable INDEX. All plotting and line printer output is done within this loop. The type of output data for value of INDEX is given below:

INDEX	Type of Data
1	Cumulative and Cumulative % Mass Loading vs. D_{50} for assumed unit density.
2	dM/dlogD vs. Geometric Mean Diameter for assumed unit density.

3	dN/dlogD vs. Geometric Mean Diameter for assumed unit density.
4	As INDEX = 1 for assumed physical density.
5	As INDEX = 2 for assumed physical density.
6	As INDEX = 3 for assumed physical density.
7	Cumulative and Cumulative % Mass Loading, dM/dlogD, and dN/dlogD Distributions as above with superimposed fitting for assumed unit density.
8	As INDEX = 7 for assumed physical density.

120: The variable INC is set equal to 2. This is the interval of records read from file 10. This means that every other record is read each time the loop from statement 730 to statement 790 (card 136 to card 325) is traversed. Data from each record read in this manner have the same density.

121-126: Determine the first and last possible record numbers, ISTRT and IEND, to be read according to the value of INDEX. For INDEX = 1, 2, 3 or 7, ISTRT = 2 and IEND = the last even numbered record containing data which is a function of the number of runs, NRUN. Since every other record is read, this results in the even records being read where the assumed density is unity. For INDEX = 4, 5, 6 or 8, ISTRT = 1 and IEND = the last odd numbered record containing data which is also a function of the number of runs, NRUN. This results in the odd records being read where the assumed density is the physical density.

127-136: The loop which begins here contains the remainder of the program (cards 127-324) and is inside the loop described above. It is controlled by the variable IAV which is equivalent to the record number IS. This loop comprises the major part of the program and controls all reading of records and all calls to subroutines which produce the desired plots.

137-177: Record IAV = IS is read to retrieve stored information on this impactor run at the assumed density.

178-179: This section calculates the record number, IREC, of file 8 which corresponds to the proper record number, IS, of file 10 and reads this record. Record IREC in file 8 contains the values of the plotting code variables which indicate the desired plots. The meaning of each of these variables J1, J2, J3, J4, J5, J6, JP1, JPCNT1, JP2, JP3, JP4, JPCNT4, JP5, and JP6 is discussed at cards 284-323. There are two records in file 10 for each run of the impactor. One is based on the assumption of physical density; the other is based on the assumption of unit density. There is one record in file 8 for these two records in file 10. It contains the value of the plotting code variables for both densities. For example, if IS = 5 or IS = 6, the corresponding record in file 8 is IREC = (IS+1)/2 = 3 corresponding to the third recorded impactor run. Note that (IS+1)/2 = 3.5 for IS = 6 but setting this equal to an integer variable truncates the fraction 0.5. The values of the plotting code variables are then read at record IREC = 3. If IREC is greater than the total number of runs, NRUN, the program has completed all graphs of the given type (as determined by the value of INDEX), and the program goes to the end of the "DO 799" loop to increment INDEX.

180-283: According to the value of INDEX, the program goes to the appropriate statement which will produce the desired graphs.

284-286: The program comes to this statement 731 (card 284) when INDEX = 1. If the plotting code variable J1 is punched as "0" in column 2 on card E, subroutine WALLY1 is called and produces a graph of cumulative mass loading of particulate less than the Stage D_{50} in milligrams per actual cubic meter, CUMG, vs. the Stage D_{50} or the lower size limit of particles on that stage in micrometers, DPC, assuming unit density. The total mass loading GRNAM, is shown at the maximum particle diameter, DMAX. The program will then return to statement 730 (card 136) to read the next record and make a similar plot either superimposed on this graph (MPLOT = 0) or on a new grid (MPLOT > 0). If there is no "next record" (IREC > NRUN), the program returns to card 119 where INDEX is incremented by one for a new type of plot.

287-289: The program goes to statement 732 (card 287) when INDEX = 2. If the plotting code variable J2 is punched as "0" in column 3 of card B, subroutine WALLY2 is called and produces a graph of dM/logD in milligrams per dry normal cubic meter, DMDLD, vs. the geometric mean diameter of particles captured on the stage in micrometers, GEOMD, assuming unit density. The program will then return to statement 730 (card 136) to read the next record and make a similar plot either superimposed on this graph (MPLOT = 0) or on a new grid (MPLOT > 0). If there is no "next record", (IREC > NRUN), the program returns to card 119 where INDEX is incremented by one for a new type of plot.

290-292: The program goes to statement 733 (card 290) when INDEX = 3. If the plotting code variable J3 is punched as "0" in column 4 of card B, subroutine WALLY3 is called and produces a graph of dN/dlogD in number of particles per dry normal cubic meter, DNDLD, vs. the geometric mean diameter of particles captured on the stage in micrometers, GEOMD, assuming unit density. The program then returns to statement 730 (card 136) to read the next record and make a similar plot either superimposed on this graph (MPLOT = 0) or on a new grid (MPLOT > 0). If there is no "next record", (IREC > NRUN), the program returns to card 119 where INDEX is incremented by one for a new type of plot.

293-295: The program goes to statement 734 (card 293) when INDEX = 4. If the plotting code variable J4 is punched as "0" in column 5 of card B, subroutine WALLY1 is called and produces the same graph as described by cards 284-286 above, except that physical density is assumed. Again, there is the option to superimpose these data on the previous grid if MPLOT = 0. After all odd records are read and each desired cumulative mass distribution graph is drawn, the program returns to card 119 where INDEX is incremented by one for a new type of plot.

296-298: The program goes to statement 735 (card 297) when INDEX = 5. If the plotting code variable J5 is punched as "0" in column 6 of Card B, subroutine WALLY2 is called and produces the same graph as described by cards 288-290 above except that physical density is assumed. The input coding for Card B is explained elsewhere. There is the option to superimpose these data on the previous grid (if MPLOT = 0). After all odd records are read and each desired mass size distribution graph is drawn, the program returns to card 119 where INDEX is incremented by one for a new type of plot.

299-301: The program goes to statement 736 (card 300) when INDEX = 6. If the plotting code variable J6 is punched as "0" in column 7 of card B, subroutine WALLY3 is called and produces the same graph as described by cards 290-292 above except that physical density is assumed. There is the option to superimpose these data on the previous grid (if MPLOT = 0). After all odd records are read and each desired cumulative mass distribution graph is drawn, the program returns to card 119 where INDEX is incremented by one for a new type of plot.

Note that for INDEX = 7, an even record (assumed unit density) is read once and then all graphs pertaining to those data are plotted without having to repeat the reading of the record for each plot. This is made possible by excluding the option to superimpose data sets. There is already a superposition of points derived directly from the particulate collected at each stage with points derived from the fitting equation or its derivative. Similarly, each odd record (assumed physical density) is read only once to produce all graphs pertaining to these data when INDEX = 8. Recall that none of the following graphs may be drawn unless for each record concerned there has been a series of continuous second degree polynomials fitted to the log 10 (cumulative mass loading of particles less than the stage D_{50}) in milligrams per actual cubic meter vs. log 10 (stage D_{50} or lower size limit of each stage) in micrometers (done by execution of program SPLIN1).

302: The program comes to this statement 737 when INDEX = 7. ISIG is set equal to a number > 0 (here ISIG = 1) in order to produce plots of points based on curve fitting superimposed on "raw data" plots.

303-304: An even record has just been read from file 10 (file KMC001) at Statement 800 (card 175) previous to reaching this statement. If the plotting code variable JP1 is punched as "0" in column 1 of card C, subroutine WALLY1 is called, and the same cumulative mass loading graph as discussed in the description of cards 284-286 is drawn. In addition, WALLY1 calls subroutine JOE1 to superimpose the cumulative mass loading curve fit to these data. This graph is for points derived assuming unit density.

305-306: INDEX is 7, and the data from the same record as above are used. If the plotting code variable JPCNT1 is punched as "0" in column 2 of card C, subroutine CUMPCT is called. This produces a probability scale vs. a common log scale on which the curve of cumulative percent of total mass loading less than the indicated particle diameter vs. the particle diameter in micrometers is plotted. This curve is dependent on the series cumulative mass loading fitting equations as used for the previous graph. This graph is for points derived assuming unit density.

307-308: INDEX is 7, and the data from the same record as above are used. If the plotting code variable JP2 is punched as "0" in column 3 of card C, subroutine WALLY2 is called, and the same dM/dlogD graph as discussed in the description of cards 287-289 is drawn. In addition WALLY2 calls subroutine JOE2 to superimpose mass size distribution points based on the derivative of the cumulative mass loading curve fit. This graph is for points derived assuming unit density.

309-313: INDEX is 7, and the data from the same record as above are used. If the plotting code variable JP3 is punched as "0" in column 4 of card C, subroutine WALLY3 is called, and the same dN/dlogD graph as discussed in the description of cards 290-292 is drawn. In addition WALLY3 calls subroutine JOE2 to superimpose the number size distribution points based on the derivative of a cumulative mass loading curve fit. This graph is for points derived assuming unit density.

314-315: The program goes to statement 738 (card 315) when INDEX = 8. An odd record has just been read from file 10 (file KMC001) at statement 800 (card 180) before reaching this statement. If the plotting code variable JP4 is punched as "0" in column 5 of card C, subroutine WALLY1 is called, and the same cumulative mass loading graph as discussed in the description of cards 284-286 is drawn except that these points are derived assuming physical density. In addition WALLY1 calls subroutine JOE1 to superimpose the cumulative mass loading curve fit for physical density to these data.

316-317: INDEX is 8, and the data from the same record as above are being used. If the plotting code variable JPCNT4 is punched as "0" in column 6 of card C, subroutine CUMPCT is called. This produces a probability scale vs. a common log scale on which the curve of cumulative percent of total mass loading less than the indicated particle diameter vs. the particle diameter in micrometers is plotted. This curve is dependent on the cumulative mass loading curve fit as used for the previous graph. This graph is for points derived assuming physical density.

318-319: INDEX is 8, and the data from the same record as above are being used. If the plotting code variable JP5 is punched as "0" in column 7 of card C, subroutine WALLY2 is called, and the same dM/dlogD graph as discussed in the description of cards 287-289 is drawn except that these points are derived assuming physical density. In addition WALLY2 calls subroutine JOE2 to superimpose the dM/dlogD points as calculated from the derivative of the cumulative mass loading curve fit for physical density.

320-323: INDEX is 8, and the data from the same record as above are being used. If the plotting variable JP6 is punched as "0" in column 8 of card C, subroutine WALLY3 is called, and the same dN/dlogD graph as discussed in the description of cards 290-292 is drawn except that these points are derived assuming physical density. In addition, WALLY3 calls JOE2 to superimpose the dN/dlogD points as calculated from the derivative of the cumulative mass loading curve fit for physical density.

Functions of the Called Subroutines

Subroutine WALLY1--

This subroutine plots the cumulative mass loading of particulate less than the stage D_{50} in milligrams per actual cubic meter and in grains per actual cubic foot vs. stage D_{50} micrometers. WALLY1 uses some plotting subroutines written especially for the DEC PDP 15/76 computer system. These routines are identified and explained in the Appendix. Of these subroutines, WALLY1 uses SCALF, XSLBL, XLOG, FCHAR, LGLBL, and YLOG.

024-025: Define π as PI = 3.1415.

026-029: Define the output device for the subroutine as M = 7 where 7 designates the output device as the plotter.

030-036: Indicate whether working with a unit density record or a physical density record. N = 1 for a physical density record (all odd records). N = 2 for a unit density record (all even records).

037-041: When ISIG = 1, subroutine WALLY1 graphs the cumulative mass loading in milligrams per actual cubic meter and in grains per actual cubic foot vs. the particle diameter as calculated directly from the mass loading of each stage. This is done in preparation for JOE1 to draw the curve fit to these points. A new grid must be drawn for each new set of data. Therefore, in this case the program goes immediately to the section of WALLY1 which draws this grid without checking MPLOT.

042: In the case where ISIG does not = 1, ISIG must = 0, and there is the possibility of superimposing 2-10 sets of data on one graph. MPLOT is checked here to see if superimposition of these data on the previous graph is desired. If this is desired, MPLOT is input as non-positive (usually MPLOT = 0), and the subroutine skips the section for drawing a new grid and proceeds to plot. If a new grid is desired, MPLOT > 0, and the subroutine continues by drawing the grid.

043-049: A new grid is to be drawn and the counter, KNT, for the n^{th} set of data drawn on that grid is reset to 0. Define the length of the horizontal x-axis or particle diameter axis XIN in inches:

XIN = 4.5

Define the length of the left perpendicular y-axis or cumulative mass loading axis YIN in inches:

YIN = 6.5

050-057: The code variable ISIZ1 $\neq$ 1, e.g. ISIZ1 = 0, when a standard number and range of cycles for each axis is desired. The program continues to define the standard maximum and minimum x-axis values and y-axis values for the cumulative mass loading graph to follow. If the code variable ISIZ1 = 1, the number and range of cycles for each axis are regulated according to the range of the data for all runs.

058-062: The maximum and minimum axis values, and therefore the number and range of cycles, are defined as standard values. XMAX and XMIN are the maximum and minimum x-axis values to be plotted. YMAX and YMIN are the maximum and minimum y-axis values to be plotted.

$$\text{YMAX} = \log_{10}(100.0) = 2.0$$

$$\text{YMAX} = \log_{10}(10{,}000) = 4.0$$

$$\text{XMIN} = \log_{10}(0.1) = -1.0$$

$$\text{YMIN} = \log_{10}(0.1) = -1.0$$

063-066: When ISIZ1 = 1, the program skips to this statement 25 (card 63). The maximum and minimum axis values, and therefore the number and range of cycles, are regulated according to the range of the data for all runs. XMIN is the common log of the minimum cut point diameter in micrometers for all runs. YMAX is the common log value of the maximum total mass loading for all runs in milligrams per actual cubic meter. YMIN is the common log of the minimum cumulative mass loading value for all runs in milligrams per actual cubic meter. Note that the value of XMAX is still standard. The function SLIM (MAXMIN, ALIMIT) finds a maximum as a function of ALIMIT when MAXMIN = 1. SLIM finds a minimum as a function of ALIMIT when MAXMIN = 0. The graphing limits are therefore:

$$XMAX = \log_{10}(100.0) = 2.0$$

$$YMAX = SLIM(1,\log_{10}(CUMAX_N))$$

where $CUMAX_N$ = the maximum total mass loading in milligrams per actual cubic meter for all runs of the same density as indicated by the value of N.

$$XMIN = SLIM(0,\log_{10}(DPMIN_N))$$

where $DPMIN_N$ = the minimum stage D_{50} in micrometers for all runs of the same density as indicated by the value of N.

$$YMIN = SLIM(0,\log_{10}(CUMIN_N))$$

where $CUMIN_N$ = the minimum cumulative mass loading in milligrams per actual cubic meter for all runs of the same density as indicated by the value of N.

067-070: Calculate the x- and y-axis scale factors, XS and YS, in inches per user's unit (i.e., inches per power of 10 for the common logarithmic scale):

XS = XIN/(XMAX-XMIN)
YS = YIN/(YMAX-YMIN)

where XIN = x-axis length in inches
YIN = y-axis length in inches
XMAX-XMIN = difference in maximum and minimum x-axis values = number of user's units along x-axis.
YMAX-YMIN = difference in maximum and minimum y-axis values = number of user's units along y-axis.

071: Define the Y-coordinate location of the pen, YORIG, when WALLY1 is called, in terms of the minimum y-axis value, YMIN (which is the Y-value at the graph origin), and the y-axis scale factor, YS, in inches per user's unit.

YORIG = YMIN - (2./YS)

The pen location should always be on the right base line of the graphing paper when any plotting subroutine is called. Therefore, the user's origin, (XMIN, YMIN) is 2 inches (or 2./YS) above the original location of the pen, (XMIN, YORIG).

072: The call to plotter subroutine SCALF (XS, YS, YMIN, YORIG) stores the number of inches per user's unit along the x- and y-axis, XS and YS, respectively, and the original location of the pen, (XMIN, YORIG), in user's units for later reference by the plotter.

073-079: This begins the section which draws the x-axis. Calculate the number of x-axis cycles IXRAN by taking the difference of the x-axis limits XMAX and XMIN:

IXRAN = XMAX - XMIN

080: The call to plotter subroutine XSLBL (XS, YS, XMIN, YMIN, IXRAN, XMIN) labels the x-axis for the $\log_{10}$ scale.

081: The call to plotter subroutine XLOG (XS, YS, XMAX, YMIN, -1, IXRAN) draws the x-axis for the $\log_{10}$ scale.

082-086: This begins the section which labels the x-axis. Define the desired width of written characters, XCS, in inches and the desired height of written characters, YCS, in inches for labeling of the x-axis:

XCS = 0.15

YCS = 0.15

087-088: Define the point (X,Y) in user's units at which the labeling of the x-axis is to begin. This position should be at the lower left-hand corner of the location at which the first character is to be drawn. In order to center the label below the x-axis, first define the X-coordinate of the beginning pen position by placing the pen at the center of x-axis length, i.e., XMIN + [(XMAX-XMIN)/2]. Multiply one-half the total number of characters to be written, including spaces, by the number of inches for each character, XCS. The label to be written is "PARTICLE DIAMETER (MICROMETERS)" which contains 32 characters. Therefore the number of inches to be "backspaced" from the center is 16·XCS. Dividing this by the inches per user's unit along the x-axis, XS, gives the number of user's units to be backspaced from the center point. Therefore:

X = XMIN + [(XMAX-XMIN)/2] + [(16·XCS)/XS].

The Y coordinate is defined far enough below the x-axis so that there is sufficient room to draw the characters (0.15 inches) without interfering with the drawn x-axis. The Y-coordinate is therefore defined as 0.7 inches below the x-axis allowing 0.55 inches between the top of the characters and the y-axis.

089: Call the plotter subroutine FCHAR (X, Y, XCS, YCS, 0.0) to initialize the annotation subroutine by establishing the starting location for the pen, (X,Y), in user's units, the height and width of the characters in inches, XCS and YCS, respectively, and the angle of writing relative to the x-axis in radians, here 0.0.

090: Write the x-axis label "PARTICLE DIAMETER (MICROMETERS)".

091-094: This begins the section which draws the y-axis on the right side of the graph. Define the Y-coordinate of the point at which this axis will begin, Y0. It does not begin at YMIN as does the left y-axis. This is because the left y-axis is in milligrams per actual cubic meter and the right y-axis is in grains per actual cubic foot. The conversion factor between these two units is 4.3702×10^{-4} grains per actual cubic foot to one milligram per dry normal cubic meter. This means that on the graph of cumulative mass loading, a value of 1 milligram per actual cubic meter on the left y-axis is parallel to 4.3702×10^{-4} grains per actual cubic foot on the right axis. In terms of the "user's units" which are common logs of these values, 0 is parallel to -3.3595. As another example, 4 (10^4 milligrams per actual cubic meter) is parallel to 0.6405 (4.3702 grains per actual cubic foot). The right y-axis is always different from the left by the $\log_{10}$ term, -3.3595. The right axis is drawn beginning with the first integral $\log_{10}$ value in grains per actual cubic foot. The fraction of a cycle, 0.3595, must be added to the Y-coordinate of the origin to locate the beginning Y-coordinate of the right y-axis, Y0:

$$Y0 = YMIN + 0.3595 \qquad (101)$$

095-097: Calculate the number of y-axis cycles IYRAN by finding the difference in the y-axis limits, YMAX and YMIN:

$$IYRAN = YMAX-YMIN \qquad (102)$$

098: Define the exponent of the first cycle in the right axis, YLEF1, by subtracting 3.0 from the first cycle on the left y-axis, YMIN. Recall that the fractional difference between these two y-axes (left and right) has been accounted for with the fraction 0.3595. Here the remaining difference in the total 3.3595 common log difference is accounted for in the labeling of each cycle:

$$YLEF1 = YMIN - 3.0 \qquad (103)$$

099: This call to plotter subroutine LGLBL (XS,YS, XMAX,Y0,IYRAN,YLEF1,0) labels the y-axis on the right side of the graph for $\log_{10}$ scale.

100: This call to plotter subroutine YLOG (XS,YS,XMAX, YMAX + 0.3595, -1, IYRAN) draws the y-axis on the right side of the graph for $\log_{10}$ scale.

101-105: This begins the section for labeling the y-axis on the right side of the graph. The pen position in user's units (X, Y) is defined for the beginning of the right y-axis label. The Y-coordinate is such that the writing will be centered along the length of the right y-axis. The X-coordinate is such that there is room for the length of the characters without interfering with the drawn right y-axis. See the discussion of cards 87-88 for a detailed example of how these are calculated:

$$X = XMAX + 0.8/YS$$

$$Y = YMIN + [(YMAX + 0.3595 - YMIN)/2 - (16 \cdot XCS)/YS] \qquad (104)$$

106: The call to plotter subroutine FCHAR (X,Y,XCS, YCS,PI/2) initializes the annotation subroutine by establishing the starting location for the pen, (X,Y), the height and width of the characters, YCS and XCS respectively, and the angle of writing in radians, here PI/2.

107: Write the y-axis label "CUMULATIVE MASS LOADING (GR/ACF)".

108-112: This begins the section for writing the identification label, ID, and the density, RHO, above the grid. Redefine the width of written characters, XCS, in inches for writing the identification label ID:

$$XCS = 0.056$$

$$YCS = 0.100$$

113-114: Define the point (X,Y) at which writing will begin for the run identification label ID as being on the parallel with the left y-axis at X = XMIN and 1/2 inch above the top of this grid at Y = YMAX + (0.5/YS).

115-119: This DO-loop searches for the last character of the identification label ID_J. This prevents any unnecessary movement of the pen for identification labels of less than 80 characters.

120: The call to plotter subroutine FCHAR (X,Y,XCS, YCS,0) initializes the annotation subroutine by establishing the starting location for the pen, (X,Y), in user's units, the height, YCS, and width, XCS, of the characters in inches, and the angle of writing in radians, here 0.0.

121: Write the identification label for the run, ID.

122-123: Redefine the beginning pen location (X,Y) in user's units for writing the density RHO. The beginning X-coordinate is defined so that the first character is in line with the left y-axis, as is the case for writing ID above. The beginning Y-coordinate is 0.25 inches above the maximum y-axis value so that with characters 0.10 inches in height there is a 5.15 inch margin between the writing for RHO and ID:

X = XMIN
Y = YMAX + (0.25/YS)

124: Call the plotter subroutine FCHAR(X,Y,XCS,YCS, 0.0) to initialize the annotation subroutine by establishing the starting location for the pen (X,Y), the width, XCS, and height, YCS, of the characters and the angle of writing in radians, here 0.0.

125: Write the assumed density, "RHO = _________."

126-129: This begins the section for drawing the y-axis on the left side of the graph. The call to plotter subroutine YLOG(XS,YS,XMIN,YMAX,-1,IYRAN) draws the y-axis on the left of the graph for $\log_{10}$ scale.

130: The call to plotter subroutine LGLBL(XS,YS,XMIN, YMIN,IYRAN,YMIN,1) labels the y-axis on the left for $\log_{10}$ scale.

131-135: This begins the section for labeling the y-axis on the left side of the graph. Redefine the width and height of written characters XCS and YCS respectively in inches for labeling the left y-axis:

$$XCS = 0.15$$

$$YCS = 0.15$$

136-137: The pen position in user's units, (X,Y), is defined for the beginning of the left y-axis label. The Y-coordinate is defined so that the writing will be centered on the midpoint of the left y-axis. The X-coordinate is defined so that the characters do not interfere with the drawn left y-axis. See the discussion of cards 087-088 for a detailed example of how these coordinates are calculated:

$$X = XMIN-(0.7/XS) \qquad (105)$$

$$Y = YMIN + [(YMAX-YMIN)/2] - [(16 \cdot XCS)/YS] \qquad (105a)$$

138: The call to plotter subroutine FCHAR(X,Y,XCS, YCS,PI/2) initializes the annotation subroutine by establishing the starting location for the pen, (X,Y), the width, XCS, and height, YCS, of the characters in inches, and the angle of writing in radians, here PI/2.0.

139: Write the left y-axis label, "CUMULATIVE MASS LOADING (MG/ACM)".

Note: The plotting grid and labeling have been drawn. Cards 140-210 are concerned with the plotting of X and Y values for cumulative mass loading in milligrams per actual cubic meter (and total grain loading in the same units) vs. the stage D_{50}'s in micrometers (and the maximum particle diameter in the same units).

140-147: The variable KNT is a code value for the number of sets of data plotted on one graph up to this point; e.g., KNT = 4 indicates that the 4th set of data is to be plotted on this grid, and a special symbol for the 4th set will be used to plot the points. Each time a new grid is drawn, KNT = 0 and the first set of data has the KNT value KNT + 1 = 0 + 1 = 1.

148-151: The first point (X, Y1) to be plotted is:

$$X1 = \log_{10} (DMAX)$$

$$Y1 = \log_{10} (GRNAM)$$

where DMAX = the largest particle diameter in micrometers.

GRNAM = the total mass loading in milligrams per actual cubic meter.

The functions XVAL(X1,XMAX,XMIN,XS) and YVAL(Y1, YMAX,YMIN,YS) check the values of X1 and Y1 respectively to see if they are within the graph boundaries XMAX, YMAX, SMIN, and YMIN. If X1 and Y1 are within XMAX-XMIN and YMAX-YMIN respectively, the original values remain unchanged so that:

XN = XVAL(X1, XMAX, XMIN, XS) = X1

YN = YVAL(Y1, YMAX, YMIN, YS) = Y1

If, however, one of the values is outside the graph limits, it is returned as a value which will be plotted 0.15 inches outside of the boundary which it exceeds. For example, for X1 = DMAX and Y1 = GRNAM:

If X1 = $\log_{10}$(DMAX) = log (100.0) = 2.0

and XMAX = $\log_{10}$(10.0) = 1.0

then XN = XVAL(X1, XMAX, XMIN, XS) =
1.0 + 0.25/XS

The plotted point (XN, YN) has a value which is 0.15 inches beyond the right y-axis and at the appropriate Y-position, $\log_{10}$ (GRNAM), assuming $\log_{10}$(GRNAM) $\leq$ YMAX.

152: The call to subroutine PIONT(KNT, XN, YN, XS, YS) plots the point (XN, YN) at the appropriate position using a symbol determined by the value of KNT.

153-158: The type of cascade impactor used is indicated by the code variable IMPAC:

IMPAC = 1 - Andersen Mark III
= 2 - Brink
= 3 - University of Washington Mark III
= 4 - Meteorology Research, Inc.

For the Brink cascade impactor there are various possible impactor configurations. Therefore, if IMPAC= 2, the program goes to statement 181 (card 159) to test for the configuration used and plot the points appropriately. If IMPAC = 1, 3, or 4, the program goes to statement 200 (card 203) to plot the points excluding checks of the configuragion in which the impactor was run.

159-175: Check for the use of the cyclone as the first stage. If it is used, MC3 = 0. The $\log_{10}$ of the cumulative mass loading of particles smaller than the cyclone D_{50}, $CUMG_1$, in milligrams per actual cubic meter and the $\log_{10}$ of the cyclone D_{50}, CYC3, in micrometers are checked in functions YVAL and XVAL. These values are altered only if they lie outside the bounds of the grid. The call to subroutine PIONT (KNT, XN, YN, XS, YS) plots the point with a symbol determined by the value of KNT. The remaining number of points to be plotted, M, depends on whether the last stage, MS, is 5, in which case M = 6, or whether the last stage MS is 6, in which case M = 7. The program then enters a loop which plots the $\log_{10}$ of the remaining non-zero cumulative mass loading values, $CUMG_J$, J=2, M+1, in milligrams per actual cubic meter vs. the $\log_{10}$ of the stage D_{50}'s, DPC_J, J = 1,M. Each $\log_{10}$ value is checked by XVAL or YVAL before plotting.

176-187: If the cyclone is not included in the Brink configuration (MC3 = 1) but stage 0 is included (M00=0), the program checks for the last stage MS and from this determines the number of points yet to be plotted, M. If the last stage MS is 5, then M = 6. If the last stage MS = 6, then M = 7. The program then enters a loop which plots the $\log_{10}$ of all non-zero cumulative mass loading values $CUMG_J$, J = 1, M in milligrams per actual cubic meter vs. the $\log_{10}$ of the stage D_{50}'s DPC_J, J = 1,M. Each $\log_{10}$ value is checked by XVAL or YVAL before plotting.

188-198: If neither the cyclone nor stage 0 is included in the Brink configuration (MC3 = 1 and M00 = 1), the program checks for the last stage, MS, and from this determines the number of points yet to be plotted, M. If the last stage MS is 5, then M = 5. If the last stage MS is 6, then M = 6. The program then enters a loop which plots the $\log_{10}$ of all non-zero cumulative mass loading values ($CUMG_J$, J = 1,M) in milligrams per actual cubic meter vs. the $\log_{10}$ of the stage D_{50}'s (DPC_J, J = 2, M+1). Each $\log_{10}$ value is checked by XVAL and YVAL before plotting.

199-210: If the Andersen, University of Washington, or Meteorology Research, Inc., impactor is used, there is only one configuration since a cyclone is not used and the first stage is always included. Therefore, the program enters the plotting loop without checking for a configuration type.

The number of points to be plotted, VV, is 8 for an Andersen impactor and 7 for the University of Washington Mark III or the MRI impactor. The $\log_{10}$ of each non-zero cumulative mass loading value, ($CUMG_J$, J = 1, VV) in milligrams per actual cubic meter, is plotted against the $\log_{10}$ of the stage D_{50}'s, (DPC_J, J = 1, VV). Each $\log_{10}$ value is checked by XVAL and YVAL before plotting.

211-233: Subroutine WALLY1 may have been called to plot only the cumulative mass loading at each stage vs. the D_{50} of each stage. In this case, ISIG = 0 and the program goes to statement 130 (card 219). There, WALLY1 calls subroutine LABEL (KNT, XS, YS, YMAX, XMIN) to write the number of this set of data plotted on this graph and the symbol used to plot this n^{th} set of data. For example, if this is the 6th set of data plotted on this one graph, LABEL causes "TEST 6 - *" to be written above the graph indicating that the symbol * is used for each point of this 6th superimposed set of data points. The pen is then returned to the base line of the plotter in the up position and 4.5 inches beyond the maximum x-axis limit. The pen is now ready for the next plot. WALLY1 returns to mainline GRAPH to seek instructions for the next graph. If ISIG = 1, the program now calls subroutine JOE1 (instead of LABEL and PIONT) to draw the cumulative mass loading curve fit to this one set of data. Only one set of data is represented on a plot for these calls to WALLY1 where ISIG = 1. After this curve is drawn on the plot and the pen returned in readiness for the next plot, JOE1 returns to mainline GRAPH to seek instruction for the next graph.

Subroutine JOE1--

This subroutine plots the curve fit to cumulative mass loading less than the stage D_{50} in milligrams per actual cubic meter vs. stage D_{50} in micrometers which was found in mainline program SPLIN1.

026-036: Read record IS from file 11 (file FILSPL) containing the information for fitting $\log_{10}$ (cumulative mass loading) vs. $\log_{10}$ (D_{50}) for this run and assumed density. These variables are the number of interval boundary points which are fitted, NPOIN, the values of these points, $(X1, Y1)_I$, I=1,NPOIN, and the series of fitting second degree polynomial coefficients, COE_{IJ}, I=1, INT, J=1,3, where INT is the number of fitted intervals = NPOIN-1.

037-049: Define the first value of the independent variable DLD as a function of the smallest stage D_{50}, DSMA, in micrometers for this run:

$$DLD = \log_{10} (DSMA)$$

Define the last value of the independent variable, DLDF, to be the common log of the maximum x-axis limit, XMAX.

$$DLDF = \log_{10} (XMAX)$$

050-055: A loop begins here at card 055 continuing to statement 750 (card 096) in which DLD = $\log_{10}$ (diameter in micrometers) is used as the independent variable in the $\log_{10}$(cumulative mass loading in milligrams per actual cubic meter) fitting equation. The resulting dependent variable is PPP, equal to the $\log_{10}$(cumulative mass loading in milligrams per actual cubic meter). At the end of the loop, DLD is incremented by a very small amount (see comment on cards 162-169). The process is repeated until DLD $\geq$ DLDF.

056-064: The "DO 20" loop here takes the diameter variable DLD and compares it with ever increasing X-coordinate values of the interval boundary points (X1, Y1), fitted in program SPLIN1, to find the interval NINT containing DLD. For example, suppose DLD = 0.135 (corresponding to a diameter of $10.0^{0.135} = 1.36458$). Also suppose $(X1, Y1)_{14} = (0.125, 2.89)$ and $(X1, Y1)_{15} = (0.148, 2.91)$. Then $X1_{14} < DLD < X1_{15}$, and the interval containing DLD is the 14th interval or NINT = 14.

065-073: The second degree polynomial curve fitting coefficients over the NINT interval $COE_{NINT,J}$, J = 1, 3, are then used to calculate the dependent variable PPP = $\log_{10}$(cumulative mass loading less than indicated diameter in milligrams per actual cubic meter):

$$PPP = COE_{NINT,1} + COE_{NINT,2}(DLD) + COE_{NINT,3}(DLD)^2 \quad (107)$$

074-083: DLD is the $\log_{10}$ (particle diameter in micrometers). PPP is the $\log_{10}$ (cumulative mass loading in milligrams per actual cubic meter). The program checks DLD and PPP in the functions XVAL and YVAL respectively, to see if their values are within the plotting bounds. If either coordinate is not within the bounds, it is assigned a value which causes the point to be plotted just outside the boundary which it exceeds.

084-087: If this is the first point to be plotted, the loop index I = 1. In this case, the pen is moved to this position and lowered by the plotter subroutine FPLOT(-2,XN,YN). Previous to execution of this instruction the pen was at the base line, 4.5 inches beyond the maximum x-axis boundary, XMAX, in the up position. This is where the pen was positioned at the closing of subroutine WALLY1 which prepared this grid for JOE1. On subsequent traverses of the loop, the plotter subroutine FPLOT (0, XN, YN) is called. This causes the pen to be moved to the new (XN, YN) position without raising or lowering the pen. Here the pen is already down, causing a solid curve to be drawn from point to point.

088-096: The value of DLD is incremented an amount corresponding to a one one-hundredth of an inch movement along the diameter axis:

$$DLD = DLD + (0.01/XS)$$

where XS = the x-axis scale factor in inches per user's units.

This new value of DLD is compared to the final $\log_{10}$ value, DLDF. If DLD $\geq$ DLDF, the program exits the loop. If DLD < DLDF, the program returns to the top of the loop at card 054 and finds the $\log_{10}$ (cumulative mass loading) for the new diameter.

097: Raise the pen by calling plotter subroutine FPLOT (+1, XN, YN).

098-106: After all plotting, the pen is moved in the up position to the base line of the plotting paper 4.5 inches beyond the maximum x-axis boundary. The plotter is now ready for the next plotting subroutine. The program returns to the calling subroutine WALLY1 which then returns to the calling mainline GRAPH.

Subroutine CUMPCT--

This subroutine plots the curve of cumulative percent mass loading less than a given diameter vs. the diameter in micrometers.

It also provides a listing on the line printer of selected diameter values in micrometers with the corresponding cumulative percent mass loading less than this particle size.

033-037: Divide the range between 0.25 micrometers and 100.0 micrometers into 70 equal $\log_{10}$ increments DINC:

$$\text{DINC} = [\log_{10}(100.00) - \log_{10}(0.25)]/70.0 = 0.0357142857 \qquad (108)$$

038-042: Define the first value of the independent variable DLD as a function of 0.25 micrometers. This is an arbitrary small particle size at which to begin the plot.

$$\text{DLD} = \log_{10}(0.25)$$

043-046: Since there are several hundred points plotted to make up the solid curve for cumulative percent mass loading vs. particle diameter, only a few specified values are printed out on the line printer. A point chosen for print out is such that the diameter is just greater than the "flag diameter variable value", Dl. Once a diameter and associated cumulative percent mass loading is printed out, Dl is redefined by repeated addition of the increment DINC. Therefore, the first Dl value is initialized here as:

$$\text{Dl} = \text{DLD} = \log_{10}(0.25)$$

In the large "DO 750" loop to follow the next Dl value is defined as:

$$\text{Dl} = \text{Dl} + \text{DINC} = \text{Dl} + 0.0357142857$$

This increment, DINC, continues to be added and values of diameter and cumulative percent mass loading less than this diameter are printed out up to the maximum diameter variable value, DLDF.

047-053: Define the last value of the independent variable

DLDF to be the maximum x-axis limit, XMAX. Recall that the x-axis (diameter) is a common log scale so that DLDF = XMAX is already in common log form.

054-062: Call subroutine CPPLOT(IC, RHO, XMAX, XMIN, YMAX, YMIN, XS, YS). CPPLOT causes the plotter to draw a probability vs. $\log_{10}$ grid, labels the axes with "CUMULATIVE PERCENT" vs. "PARTICLE DIAMETER (MICROMETERS)", writes the identification label for the run ID and particle density in grams per cubic centimeter, RHO, above the grid, and returns with the minimum and maximum axis values XMAX, XMIN, YMAX, and YMIN and the scale factors XS and YS in inches per user's unit.

063-072: Read record number IS from file 11 (file FILSPL) containing the information for fitting $\log_{10}$ (cumulative mass loading) vs. $\log_{10}$ (D_{50}) for this run and assumed density. These variables are the number of interval boundary points which are fitted, NPOIN, the values of these points, $(X1,Y1)_I$, I = 1,NPOIN, and the series of fitting second degree polynomial coefficients, COE_{IJ}, I=1,INT, J=1,3. INT = NPOIN-1 is the number of fitted intervals.

073-077: Write the identification label, ID, and density, RHO, in grams per cubic centimeter at the top of the page on the line printer.

078-085: A loop begins here at card 085 continuing to statement 750 (card 176) in which DLD = $\log_{10}$ (diameter in micrometers) is used as the independent variable to find the resulting dependent variable, PPP = $\log_{10}$ (cumulative mass loading in milligrams per actual cubic meter). The interval NINT containing DLD is first found.

Then the DLD value is used as the independent variable in the second degree polynomial fitting this range of $\log_{10}$ (cumulative mass loading) vs. $\log_{10}$ (diameter). Changes of variable are made for plotting and printing. PPP is converted to cumulative fractional mass loading. DPLOT is defined as DLD = $\log_{10}$ (diameter). These are the plotting variables. At previously defined intervals there is another change of variable for printing. PPP is converted to cumulative percent mass loading and DPLOT is converted to diameter. The variable D1 = $\log_{10}$ (diameter) is incremented each time through the loop when there is line printer output. The independent variable DLD = $\log_{10}$ (diameter) is incremented each time through the loop. The process is repeated until DLD $\geq$ DLDF.

086-094: The "DO 510" loop here takes the diameter variable DLD and compares it to ever increasing X-coordinate values of the interval boundary points, (X1,Y1) fitted in program SPLIN1, to find the interval, NINT, containing DLD.

095-100: The second degree polynomial curve fitting coefficients over the NINT interval, $COE_{NINT,J}$, J=1,3 are used here to calculate PPP = $\log_{10}$ (cumulative mass loading less than indicated diameter in milligrams per actual cubic meter):

$$PPP = COE_{NINT,1} + COE_{NINT,2}DLD + COE_{NINT,3}(DLD)^2 \qquad (109)$$

101-106: Convert PPP from $\log_{10}$ (cumulative mass loading less than indicated diameter in milligrams per actual cubic meter) to cumulative fractional mass loading less than indicated diameter. First convert PPP to cumulative mass loading less than indicated diameter in milligrams per actual cubic meter, and then divide this quantity by the total mass loading in the same units, GRNAM:

$$PPP = 10.0^{PPP}/GRNAM \tag{110}$$

107-110: Define the plotting abscissa value, DPLOT, to be the same as the independent variable DLD.

111-115: The call to subroutine NDTRI (PPP, YV, D, IE) returns the ordinate value to be plotted, YV, in terms of the probability scale. This is a subroutine from the IBM 360 Scientific Subroutine Package.

116-125: Two statements check YV to see if it is within the limits of plotting on the probability scale. If YV is greater than the upper limit, 0.9999 (or 99.99 percent), YV is given an arbitrary value (here, +4) which is greater than the equivalent upper limit on the probability scale which is +3.719244. If YV is less than the lower limit of 0.0001 (or 00.01 percent), it is given an arbitrary value (here, -4) which is less than the lower limit on the probability scale which is -3.7191244.

126-132: DPLOT and YV are checked by the functions XVAL and YVAL respectively. The functions do not change any value which is within the limits of plotting so that the plotted point (XN, YN) = (DPLOT, YVAL). Any value outside these limits (e.g., YV = 4 or -4) is assigned a value which causes the point (XN, YN) to be plotted 0.15 inches beyond the axis limit which it exceeds.

133-140: If this is the first point to be plotted, the loop index I = 1. In this case, the pen is moved to the first point and lowered by the plotter subroutine FPLOT (-2, XN, YN). The pen is in the up position previous to this instruction. On subsequent traverses of the loop, the plotter subroutine FPLOT (0, XN, YN) is called. This causes the pen to be moved to the new (XN, YN) position without raising or lowering the pen. Here the pen is already down, causing a solid curve to be drawn from point to point.

141-146: Compare the diameter variable D1 with the value of the diameter variable DLD. After a sufficient number of loop traverses where DLD is incremented each time, DLD $\geq$ D1. This is the signal for line printer output of the plotted values. Otherwise this printing section (cards 147-165) is skipped.

147-156: When DLD $\geq$ D1, there is a change of variable for the line printer output. DPLOT is converted from the plotted form $\log_{10}$ (diameter) to diameter:

$$\text{DPLOT} = 10.0^{\text{DPLOT}} \tag{111}$$

The variable PPP is converted from cumulative fractional mass loading to cumulative percent mass loading:

$$\text{PPP} = 100 \times \text{PPP} \tag{112}$$

The line printer point index number J is incremented with each new printing:

$$J = J + 1 \tag{113}$$

157-161: Write the point index number, J, the diameter in micrometers, DPLOT, and the cumulative percent mass loading, PPP, on the line printer. Thus, the result of many traverses of the loop is a table of diameter values and corresponding cumulative percent mass loadings of particulate less than this indicated diameter. The diameters range from 0.25 micrometers up to approximately the antilog of the x-axis maxmimum limit, 10.0^{XMAX}.

162-169: After each printing, the diameter variable D1 is incremented by DINC (as defined at card 037). The diameter variable DLD is incremented only by the value equivalent to one one-hundredth of an inch movement along the $\log_{10}$ diameter axis. This is a much smaller increment than DINC. Thus D1 continues to be greater than DLD until several traverses of the loop have taken place. When DLD again is $\geq$ D1, there is another printing of values.

170-176: The value of DLD is compared to the maximum desired plotted value, DLDF. If DLD $\geq$ DLDF, the program exits this "DO 750" loop which began at card 084. If DLD < DLDF, the loop is repeated.

177-183: After all plotting and printing is completed, raise the pen and move it to the base line of the plotter 4.5 inches beyond the maximum x-axis limit, XMAX. The pen is now ready for the next plotting subroutine. Return to the calling mainline program GRAPH.

Subroutine WALLY2--

This subroutine plots the $\Delta M/\Delta \log D$ distribution values in milligrams per dry normal cubic meter vs. the geometric mean diameter of particles on each stage in micrometers.

024-025: Define the angle π in radians as PI = 3.1415.

026-029: Define the output device for the subroutine as M = 7, where 7 designates the output device as the plotter.

030-036: The code variable N indicates the assumed density. If the assumed density is the physical density, then N = 1, and the data input to WALLY2 is taken from an odd numbered record. If the assumed density is unit density, then N = 2, and the data input to WALLY2 is taken from an even numbered record.

037-042: When ISIG = 1, graphing is not completed when WALLY2 plots the $\Delta M/\Delta \log D$ distribution in milligrams per dry normal cubic meter vs. the geometric mean diameter of particles on each stage in micrometers. This is done in preparation for JOE2 to plot the dM/dlogD distribution as calculated from the derivative of the fitted cumulative mass loading equation. A new grid must be drawn for each new set of data. Therefore the program goes immediately to the section of WALLY2 which draws this grid without checking MPLOT.

043: In the case where ISIG = 0, there is the possibility of superimposing 2-10 sets of data on one grid. MPLOT is checked here to see if superimposition of these data on the previous graph is desired. In that case MPLOT is non-positive (usually MPLOT=0). The subroutine skips the section for drawing a new grid and proceeds to plot. If a new grid is desired, MPLOT > 0, and the subroutine continues by drawing the grid.

044-050: A new grid is to be drawn and the counter for the n^{th} set of data drawn on that grid, KNT, is reset to 0 at statement 20 (card 048). Define the length XIN of the horizontal x-axis or particle diameter axis in inches:

XIN = 4.5

Define the length YIN of the perpendicular y-axis or mass size distribution axis in inches:

YIN = 6.5

051-057: If the code variable ISIZ2 ≠ 1 (usually ISIZ2 =

0 in this case), standard number and range of cycles for each axis is desired. The program defines the standard maximum and minimum x-axis values and y-axis values for the mass size distribution graph to follow. If the code variable ISIZ2 = 1, it is desired that the number and range of cycles for each axis be regulated according to the range of the data for all runs.

058-068: The maximum and minimum limits for the ordinate and abscissa are defined as standard values here. XMAX and XMIN are the maximum and minimum x-axis values to be plotted. The standard values for XMAX and XMIN are the same regardless of the impactor used. They are:

$$\text{XMAX} = \log_{10}(100.0) = 2.0 \tag{114}$$

$$\text{XMIN} = \log_{10}\ (0.1) = -1.0 \tag{115}$$

YMAX and YMIN are the maximum and minimum y-axis values to be plotted. The standard YMAX and YMIN values are dependent on the impactor used. For both the Andersen (IMPAC = 1), the University of Washington Mark III (IMPAC = 3), and the Meteorology Research, Inc., cascade impactors, these values are:

$$\text{YMAX} = \log_{10}\ (10^{4}) = 4.0 \tag{116}$$

$$\text{YMIN} = \log_{10}\ (10^{-2}) = -2.0 \tag{117}$$

For the Brink cascade impactor (IMPAC = 2), these values are:

$$\text{YMAX} = \log_{10}\ (10^{6}) = 6.0 \tag{118}$$

$$\text{YMIN} = \log_{10}\ (1.0) = 0.0 \tag{119}$$

069-072: ISIZ2 = 1 and the program skips to statement 25 (card 069). The maximum and minimum axis values and therefore the number and range of cycles are regulated according to the range of the data for all runs. In this case, XMIN is the common log value of the minimum geometric mean diameter sizes for all runs in micrometers. YMAX and YMIN are the common logs of the maximum and minimum values for all runs of the mass size distribution in milligrams per dry normal cubic meter. Note that the value of XMAX is still standard. The function SLIM (MAXMIN, ALIMIT) rounds ALIMIT to the next higher integer when MAXMIN=1. SLIM truncates ALIMIT to the next lower integer when MAXMIN=0. Thus:

$$\mathrm{XMAX} = \log_{10}(100.0) = 2.0 \tag{120}$$

$$\mathrm{YMAX} = \mathrm{SLIM}\ (1,\log_{10}(\mathrm{DMAX}_N)) \tag{121}$$

$$\mathrm{XMIN} = \mathrm{SLIM}\ (0,\log_{10}(\mathrm{GEMIN}_N)) \tag{122}$$

$$\mathrm{YMIN} = \mathrm{SLIM}\ (0,\log_{10}(\mathrm{DMMIN}_N)) \tag{123}$$

where DMMAX_N = the maximum value of the $\Delta M/\Delta \log D$ distribution in milligrams per dry normal cubic meter for all runs of the same density, as indicated by the value of N.

GEMIN_N = the minimum geometric mean diameter in micrometers for all runs of the same density, as indicated by the value of N.

DMMIN_N = the minimum value of the $\Delta M/\Delta \log D$ distribution in milligrams per dry normal cubic meter for all runs of the same density as indicated by the value of N.

073-077: Calculate the x- and y-axes scale factors, XS and YS respectively, in inches per user's unit (i.e., inches per power of 10 on a natural logarithmic scale):

$$\mathrm{XS} = \mathrm{XIN}/(\mathrm{XMAX}-\mathrm{XMIN}) \tag{124}$$

$$\mathrm{YS} = \mathrm{YIN}/(\mathrm{YMAX}-\mathrm{YMIN}) \tag{125}$$

where XIN = x-axis length in inches

YIN = y-axis length in inches (126)

XMAX - XMIN = difference in maximum and minimum x-axis values = number of user's units along x-axis (127)

YMAX - YMIN = difference in maximum and minimum y-axis values = number of user's units along y-axis (128)

078: When WALLY2 is called, define the Y-coordinate location of the pen, YORIG, in terms of the minimum y-axis value YMIN (Y-value at the origin) and the y-axis scale factor, YS, in inches per user's unit:

YORIG = YMIN - (2/YS) (129)

The pen location should always be on the base line of the graphing paper when any plotting subroutine is called. Therefore, the user's origin, (XMIN, YMIN), is 2 inches, (2/YS), above the original location of the pen, (XMIN, YORIG).

079: The call to plotter subroutine SCALF (XS, YS, YMIN, YORIG) stores x- and y-axes scale factors XS and YS in inches per user's unit, and the original location of the pen (XMIN, YORIG), in user's units for later reference by the plotter.

080-086: This begins the section which draws the x-axis using a common log scale. Find the number of x-axis cycles, IXRAN, by calculating the difference of the x-axis limits XMAX and XMIN:

IXRAN = XMAX - XMIN (130)

087: The call to plotter subroutine XSLBL (XS, YS, XMIN, YMIN, IXRAN, XMIN) labels the x-axis for $\log_{10}$ scale.

088: The call to plotter subroutine XLOG (XS, YS, XMAX, YMIN, -1, IXRAN) draws the x-axis for $\log_{10}$ scale.

089-093: This begins the section which labels the x-axis cycles. Define the desired width and length of written characters in inches, XCS and YCS, for labeling the x-axis:

XCS = 0.15
YCS = 0.15

094-095: Define the point (X, Y) in user's units at which the labeling of the x-axis is to begin. This location should be at the lower left-hand corner of the position at which the first character is to be drawn. In order to center the label below the x-axis, first define the X-coordinate of the beginning pen position by placing the pen at the center of the x-axis length, i.e., XMIN + (XMAX -XMIN)/2.0. Multiply 1/2 the total number of characters to be written (including spaces) by the number of inches for each character, XCS. The label to be written is "PARTICLE DIAMETER (MICROMETERS)" which contains 32 characters. Therefore, the number of inches to be backspaced from the center is 16·XCS. Dividing this by the inches per user's unit along the x-axis XS, one obtains the number of user's units to be backspaced from the center point. Therefore:

$$X = XMIN + [(XMAX-XMIN)/2] - [(16 \cdot XCS)/XS] \quad (131)$$

The Y-coordinate is defined far enough below the x-axis so that there is room enough to draw characters (0.15 inches) without interfering with the drawn x-axis. The Y-coordinate is therefore 0.7 inches below the x-axis which allows 0.55 inches between the top of the characters and the y-axis:

$$Y = YMIN - (0.7/YS) \quad (132)$$

096: Call the plotter subroutine, FCHAR (X,Y,XCS, YCS,0.0), to initialize the annotation subroutine by establishing the starting location for the pen, (X,Y) in user's units, the width and height of the characters in inches, XCS and YCS, and the angle of writing in radians relative to the x-axis, here 0.0.

097: Write the x-axis label, "PARTICLE DIAMETER (MICROMETERS)".

098-102: This begins the section which writes above the graph the identification label, ID, and assumed density, RHO, in grams per cubic centimeter. Redefine the width and height of written characters in inches, XCS and YCS, for writing the identification label ID:

XCS = 0.056
YCS = 0.100

103-104: Define the point (X,Y) at which writing will begin for the run identification label ID as being in line with the y-axis at X = XMIN and 0.5 inch above the grid at Y = YMAX + (0.15/YS).

105-109: This DO-loop searches for the last character of the identification label ID_J. This prevents any unnecessary movement of the pen for identification labels of less than 80 characters.

110: The call to plotter subroutine FCHAR (X,Y,XCS, YCS,0.0) initializes the annotation subroutine by establishing the starting location for the pen (X,Y) in user's units, the width and height of the characters in inches, XCS and YCS, and the angle of writing in radians, 0.0.

111: Write the identification label, ID, for the run.

112-113: Redefine the beginning pen location (X,Y) in user's units for writing the density, RHO. The beginning X-coordinate is defined so that the first character is in line with the y-axis, as is the case for writing ID above. The beginning Y-coordinate is 0.25 inches above the maximum y-axis value so that with characters 0.1 inch in height, there is a 0.15 inch margin between the writing for RHO and ID:

X = XMIN

Y = YMAX + (0.25/YS)

114: Call the plotter subroutine FCHAR (X,Y,XCS,YCS, 0.0) to initialize the annotation subroutine by establishing the starting location for the pen (X,Y) in user's units, the width and height of the characters in inches, XCS and YCS, and the angle of writing in radians, with respect to the x-axis, here 0.0.

115: Write the assumed density "RHO = _________".

116-121: This begins the section for drawing the y-axis on the left side of the graph using a common log scale. Calculate the number of y-axis cycles, IYRAN, by taking the difference of the y-axis limits YMAX and YMIN:

IYRAN = YMAX-YMIN (133)

122: The call to plotter subroutine YLOG (XS,YS, XMIN,YMAX,-1,IYRAN) draws the y-axis on the left of the graph for a common log scale.

123: The call to plotter subroutine LGLBL (XS,YS, XMIN,YMIN,IYRAN,YMIN,1) labels the y-axis on the left for a common log scale.

124-128: This begins the section for labeling the y-axis with powers of ten. Redefine the width and height in inches of written characters XCS and YCS for labeling the y-axis:

XCS = 0.15

$$YCS = 0.15$$

129-130: The pen position in user's units, (X,Y) is defined for the beginning of the y-axis label. The Y-coordinate is defined so that the writing is centered on the midpoint of the y-axis. The X-coordinate is defined so that the base of the characters does not interfere with the drawn y-axis. See the discussion of cards 094-095 for a detailed example of how these coordinates are calculated:

$$X = XMIN - (0.7/XS) \tag{134}$$

$$Y = YMIN + [(YMAX-YMIN)/2.0] - [16 \cdot XCS)/YS] \tag{135}$$

131: The call to plotter subroutine FCHAR (X,Y,XCS, YCS,PI/2) initializes the annotation subroutine by establishing the starting location of the pen (X,Y), in user's units, the width and height of the characters in inches, XCS and YCS, and the angle of writing in radians, here $\pi/2$.

132: Write the y-axis label "DM/DLOGD (MG/DNM3)".

Note: The plotting grid and labeling have been drawn. Cards 137-146 are concerned with the plotting of X and Y values for the dM/dlogD distribution vs. the geometric mean diameter of the particles at each of these stages, in micrometers.

133-137: The variable KNT is a code value for the number of sets of data plotted on one graph up to this point. For example KNT=4 indicates that this is the 4th set of data to be plotted on this grid, and a special symbol for the 4th set is to be used to plot the points. Each time a new grid is drawn, KNT is reset to zero and the first set of data has the KNT value KNT+1=0+1=1.

138: The number of points to be plotted on this graph of mass size loading vs. geometric mean diameter, IV, is one more than that plotted for the total mass loading vs. maximum particle diameter plus the number of cumulative mass loading vs. D_{50} points, VV. This is because a value of the mass size distribution and corresponding geometric mean diameter can be expressed for the particulate matter collected on the back up filter. However, there is no cumulative mass loading which escapes the back up filter and no lower size limit for the back up filter since it captures all remaining particulate. IV=8 for both the University of Washington and Meteorology Research, Inc. cascade impactors, and IV=9 for both the Andersen and Brink cascade impactors.

139-146: The program enters a loop to plot the $\log_{10}$ of all non-zero values of the $\Delta M/\Delta \log D$ distribution, $DMDLD_J$, J=1, IV in milligrams per dry normal cubic meter vs. the $\log_{10}$ of all non-zero values of the geometric mean diameter of the particles at each stage in micrometers, $GEOMD_J$, J=1, IV. If the values at a given stage are zero, the point cannot be represented on the plot since $\log_{10}$ (0.0) is undefined. Each common log value is checked by XVAL or YVAL to see if the point is within the grid boundaries. If one of the points' coordinates exceeds a boundary, it is given a value which will cause the point to be plotted 0.15 inch outside the boundary. Subroutine PIONT(KNT,XN,YN,XS,YS) actually plots the point with a symbol determined by the value of KNT.

147-169: Subroutine WALLY2 may be called only to plot the values of the $\Delta M/\Delta \log D$ distribution vs. the geometric mean diameter based on the mass captured on each stage. In this case, ISIG=0, and the program then continues by calling subroutine LABEL(KNT,XS,YS,YMAX,YMIN) to write the number of this set of data plotted on the graph and the symbol used to plot the n^{th} set of data. For example, if this is the 6th set of data plotted on one graph, LABEL causes "TEST 6-*" to be printed above the graph indicating that the symbol * used for each point of this 6th superimposed set of data points. The pen is then returned in the up position to the base line of the plotter and 4.5 inches beyond the maximum x-axis limit. It is now prepared for the next plot. WALLY2 returns to mainline GRAPH to seek instructions for the next graph. If ISIG=1, the program now calls subroutine JOE2 (instead of LABEL and PIONT) to plot the points for dM/dlogD distribution vs. geometric mean diameter as calculated from the derivative of the cumulative mass loading curve fit. Only one set of data is represented on a plot for these calls to WALLY2 where ISIG=1. After these points are plotted and the pen returned in readiness for the next plot, JOE2 returns to WALLY2. WALLY2 then returns to mainline GRAPH to seek instructions for the next plot.

Subroutine WALLY3--

This subroutine plots the $\Delta N/\Delta \log D$ distribution values in number of particles per dry normal cubic meter vs. the geometric mean diameter of the stages in micrometers.

024: Define the radian angle π as PI = 3.1415.

025: Define the output device for the subroutine as M = 7 where 7 designates the output as the plotter.

026-027: The code variable N indicates the assumed density. If the assumed density is physical density, then N = 1 and the data input to WALLY3 is from an odd numbered record. If the assumed density is unit density, then N = 2 and the data input to WALLY3 is from an even numbered record.

028-032: When ISIG > 0 (ISIG=6 in this subroutine), graphing is not completed when WALLY3 plots the $\Delta N/\Delta$-logD distribution in number of particles per dry normal cubic meter vs. the geometric mean diameter of particles on each stage in micrometers. This is done in preparation for JOE2 to plot the dN/dlogD distribution as calculated from the derivative of the cumulative mass loading fitted equation. A new grid must be drawn for each new set of data. Therefore the program goes immediately to the section of WALLY3 (statement 20, card 034) which draws this grid without checking MPLOT.

033: In the case where ISIG $\leq$ 0, there is the possibility of superimposing from 2-10 sets of data on one graph. MPLOT is checked here to see if superimposition of these data on the previous graph is desired. In that case MPLOT is non-positive (usually MPLOT = 0). The subroutine skips the section for drawing a new grid and proceeds to plot. If a new grid is desired, MPLOT > 0, and the subroutine continues by drawing the grid.

034: A new grid is to be drawn and the counter for the n^{th} set of data drawn on that grid, KNT, is reset to 0 at XIN, statement 20.

035-040: Define the length of the horizontal x-axis or particle diameter axis in inches.

$$XIN = 4.5$$

Define the length YIN of the perpendicular y-axis or number size distribution axis in inches:

$$YIN = 6.5$$

041-047: If the code variable $ISIZ3 \neq 1$, a standard number and range of cycles for each axis is desired. The program keeps the standard maximum and minimum x-axis values and y-axis values for the $\Delta N/\Delta \log D$ or $dN/d\log D$ distribution graph to follow. If the code variable ISIZ3=1, the number and range of cycles for each axis will be regulated according to the range of the data for all runs.

048-058: The maximum and minimum axis values, and therefore the number and range of cycles are defined as standard values. XMAX and XMIN are the maximum and minimum x-axis values to be plotted. The standard values for XMAX and XMIN are the same regardless of the impactor used. They are:

$$XMAX = \log_{10} (100.0) = 2.0 \qquad (136)$$

$$XMIN = \log_{10} (0.1) = -1.0 \qquad (137)$$

YMAX and YMIN are the maximum and minimum y-axis values to be plotted. These standard YMAX and YMIN values are dependent on the impactor used. For the Andersen (IMPAC = 1), the University of Washington Mark III (IMPAC = 3), and the Meteorology Research, Inc., cascade impactors, these values are:

$$YMAX = \log_{10} (10^{15}) = 15 \qquad (138)$$

$$YMIN = \log_{10} (10^{6}) = 6 \qquad (139)$$

For the Brink cascade impactor (IMPAC = 2) these values are:

$$YMAX = \log_{10} (10^{14}) = 14 \qquad (140)$$

$YMIN = \log_{10} (10^5) = 5$

059-062: ISIZ3 = 1 and the program goes to statement 25 (card 59). The maximum and minimum axis values, and therefore the number of range of cycles, are regulated according to the range of the data for all runs. XMIN is the common log value of the minimum geometric mean diameter for all runs in micrometers. YMAX and YMIN are the common logs of the maximum and minimum values for all runs of the $\Delta N/\Delta \log D$ or $dN/d\log D$ distribution in number of particles per dry normal cubic meter. Note that XMAX is still set to the standard value. The function SLIM (MAXMIN, ALIMIT) rounds the variable ALIMIT to the next higher integer when MAXMIN = 1. SLIM truncates ALIMIT to the next lower integer when MAXMIN = 0. Thus:

$$XMAX = \log_{10} (100.0) = 2.0 \qquad (141)$$

$$YMAX = SLIM\ (1,\log_{10}(DNMAX_N)) \qquad (142)$$

$$XMIN = SLIM\ (0,\log_{10}(GEMIN_N)) \qquad (143)$$

$$YMIN = SLIM\ (0,\log_{10}(DMMIN_N)) \qquad (144)$$

where $DNMAX_N$ = the maximum value of the dN/dlogD distribution in number of particles per dry normal cubic meter for all runs of the same density, as indicated by the value of N.

$GEMIN_N$ = the minimum geometric mean diameter in micrometers for all runs of the same density as indicated by the value of N.

$DNMIN_N$ = the minimum value of the dN/dlogD distribution in number of particles per dry normal cubic meter for all runs of the same density, as indicated by the value of N.

063-067: Calculate the x and y axis scale factors, XS and YS, in inches per user's unit (i.e., inches per power of 10 on a common logarithmic scale):

XS = XIN/(XMAX-XMIN) (145)

YS = YIN/(YMAX-YMIN) (146)

where XIN = x-axis length in inches (147)

YIN = y-axis length in inches (148)

XMAX-XMIN = difference in maximum and minimum y-axis values = number of user's units along y-axis. (149)

068: When WALLY3 is called, define the Y-coordinate location of the pen, YORIG, in terms of the minimum y-axis value, YMIN, (i.e., Y-value at the graph origin) and the y-axis scale factor, YS, inches per user's units:

YORIG = YMIN - (2./YS) (150)

The location should always be on the base line of graphing paper when any plotting subroutine is called. Therefore, the user's origin, (XMIN,YMIN) is 2 inches, i.e. (2/YS), above the original location of the pen, (XMIN, YORIG).

069: The call to plotter subroutine SCALF (XS,YS,YMIN, YORIG) stores x and y axis scale factors, XS and YS, in inches per user's unit, and the original location of the pen (XMIN,YORIG) in user's units, for later reference by the plotter.

070-076: This begins the section for drawing the x-axis using a common log scale. Calculate the number of x-axis cycles, IXRAN, by calculating the difference of the x-axis limits XMAX and XMIN:

IXRAN = XMAX-XMIN (151)

077: The call to plotter subroutine, XSLBL (XS,YS, XMIN,YMIN,IXRAN,YMIN) labels the x-axis for the log$_{10}$ scale.

078: The call to plotter subroutine XLOG (XS,YS, XMAX,YMIN,-1,IXRAN) draws the x-axis for the $\log_{10}$ scale.

079-083: This begins the section for labeling the x-axis cycles. Define the desired width and height of written characters in inches, XCS and YCS:

XCS = 0.15
YCS = 0.15

084-085: Define the point (X,Y) in user's units at which the labeling of the x-axis is to begin. This location should be at the lower left-hand corner of the position where the first character is to be drawn. In order to center the label below the x-axis, first define the X-coordinate of the beginning pen position by placing the pen at the center of the x-axis length, i.e. XMIN + [(XMAX-XMIN)/2]. Multiply 1/2 the total number of characters to be written, including spaces, by the number of inches for each character, XCS. The label to be written in "PARTICLE DIAMETER (MICROMETERS)" which contains 32 characters. Therefore, the number of inches to be "backspaced" from the center is 16·XCS. Dividing this by the inches per user's unit along the x-axis, XS, gives the number of user's units to be backspaced from the center point. Therefore:

$$X = XMIN + [(XMAX-XMIN)/2] - [(16 \cdot XCS)/XS]. \qquad (152)$$

The Y-coordinate is defined low enough below the x-axis so that there is room enough to draw the characters (0.15 inches) without interfering with the drawn x-axis. The Y-coordinate is therefore defined as 0.7 inches below the x-axis allowing 0.55 inches between the top of the characters and the y-axis.

$$Y = YMIN - (0.7/YS) \tag{153}$$

086: Call the plotter subroutine FCHAR (X,Y,XCS,YCS, 0.0) to initialize the annotation subroutine by establishing the starting location for the pen, (X,Y), in user's units, the width and height of the characters in inches, XCS and YCS respectively, and the angle of writing relative to the x-axis, here 0.0 radians.

087: Write the x-axis label "PARTICLE DIAMETER (MICROMETERS)".

088-092: This begins the section for writing the identification label, ID, and the assumed density, RHO, above the graph. Redefine the width and height of written characters in inches, XCS and YCS, for writing the run identification label, ID:

XCS = 0.056

YCS = 0.100

093-094: Define the point (X,Y) at which writing will begin for the run identification label, ID, as being in line with the Y-axis at X=XMIN and 1/2 inch above the top of the grid at Y=YMAX + (0.5/YS).

095-099: This DO-loop searches for the last character of the identification label, ID_J. This prevents any unnecessary movement of the pen for identification labels of less than 80 characters.

100: The call to plotter subroutine FCHAR (X,Y,XCS, YCS,0.0) initializes the annotation subroutine by establishing the starting location for the pen, (X,Y), in user's units, the width and height of the characters in inches, XCS and YCS respectively, and the angle of writing, here 0.0 radians.

101: Write the identification label, ID, for the run.

102-103: Redefine the beginning pen location, (X,Y), in user's units for writing the density, RHO. The beginning X-coordinate is defined so that the first character is in line with the y-axis, as is the case for writing ID above. The beginning Y-coordinate is 0.25 inches above the maximum y-axis value so that with characters 0.10 inches in height, there is a 0.15 inch margin between the writing for RHO and ID:

$$X = XMIN \qquad (154)$$

$$Y = YMAX + (0.25/YS) \qquad (155)$$

104: Call the plotter subroutine FCHAR (X,Y,XCS,YCS, 0.0) to initialize the starting location for the pen, (X,Y) in user's units, the width and height of characters in inches, XCS and YCS, and the angle of writing, here 0.0 radians.

105: Write the assumed density "RHO = _________".

106-111: This begins the section for drawing the y-axis on the left side of the graph using a common log scale. Calculate the number of y-axis cycles, IYRAN, by taking the difference of the y-axis limits YMAX and YMIN:

$$IYRAN = YMAX-YMIN \qquad (156)$$

112: The call to plotter subroutine YLOG (XS,YS,XMIN, YMAX,-1,IYRAN) draws the y-axis on the left of the graph for common log scale.

113: The call to plotter subroutine LGLBL (XS,YS,XMIN, YMIN,IYRAN,YMIN,1) labels the y-axis on the left for common log scale.

114-118: This begins the section for labeling the y-axis on the left side of the graph with cycles. Redefine the width and height of written characters in inches, XCS and YCS, for labeling the y-axis:

$XCS = 0.15$

$YCS = 0.15$

119-120: The pen position in user's units, (X,Y), is defined for the beginning of the y-axis label. The Y-coordinate is defined so that the writing will be centered on the midpoint of the y-axis. The X-coordinate is defined so that the base of the characters does not interfere with the drawn y-axis. See the discussion of cards 084-085 for a detailed example of how these coordinates are calculated:

$$X = XMIN - (0.7/XS) \tag{157}$$

$$Y = YMIN + [(YMAX-YMIN)/2.0] - [16 \cdot XCS)/YS] \tag{158}$$

121: The call to plotter subroutine FCHAR (X,Y,XCS, YCS,PI/2) initializes the annotation subroutine by establishing the starting location of the pen (X,Y) in user's units, the width and height of the characters in inches, XCS and YCS and the angle of writing, here $\pi/2$ radians.

122: Write the y-axis label "DN/DLOGD (NO. PARTICLES/ DNM3)".

Note: The plotting grid and labeling have been drawn. Cards 123-135 are concerned with the plotting of X and Y values for the $\Delta N/\Delta \log D$ distribution vs. the geometric mean diameter of the particles at each of these stages in micrometers.

123-126: The variable KNT is a code value for the number of sets of data plotted on one graph up to this point. For example, KNT = 4 indicates that this is the 4th set of data to be plotted on this grid, and a special symbol for the 4th set will be used to plot the points. Each time a new grid is drawn, KNT = 0, and the first set of data has the KNT value, KNT + 1 = 0 + 1 = 1.

127: The number of points, IV, to be plotted on this graph of ΔN/ΔlogD vs. geometric mean diameter is defined here. It is one more than VV which is the number of possible cumulative mass loadings at each D_{50} plus one for total mass loading at the maximum particle diameter. This is because a value of the ΔN/ΔlogD distribution and corresponding geometric mean diameter can be expressed for particulate matter collected on the back up filter. However, there is no mass which escapes the back up filter since it captures all remaining particles. IV = 8 for both the University of Washington Mark III and the Meteorology Research, Inc., cascade impactors, and IV = 9 for both the Andersen and Brink cascade impactors.

128-135: The program enters a loop to plot the common log of all non-zero values of the number size distribution, $DNDLD_J$, J = 1, IV, in number of particles per dry normal cubic meter vs. the common log of all non-zero values of the geometric mean diameter of the particles at each stage in micrometers, $GEOMD_J$, J = 1, IV. If the values at a given stage are zero, the point cannot be represented on the plot since $\log_{10}$ (0.0) is negative infinity. Each common log value is checked by XVAL or YVAL to see if the point is within the grid boundaries. If one of the point's coordinates exceeds a boundary, it is given a value which will cause the point to be plotted at 0.15 inches outside the boundary. Subroutine PIONT (KNT,XN,YN,XS,YS) actually plots the point with a symbol determined by the value of KNT.

136-146: Subroutine WALLY3 may have been called to plot the values of the ΔN/ΔlogD distribution vs. the geometric mean diameter based on the mass captured at each stage exclusively. In this case ISIG = 0, and WALLY3 calls subroutine LABEL (KNT, XS,YS,YMAX,YMIN) to write the number of this set of data plotted on this graph and the symbol used to plot this n^{th} set of data. For example, if this is the 6th set of data plotted on this one graph, LABEL causes "TEST 6-*" to be printed above the graph indicating that the symbol * is used for each point of this 6th superimposed set of data points. The pen is then returned in the up position to the baseline of the plotter, 4.5 inches beyond the maximum x-axis limit. It is now ready for the next plot. WALLY3 returns to mainline GRAPH to seek instructions for the next graph. If ISIG = 6, the program calls subroutine JOE2 (instead of LABEL and PIONT) to plot the points for the dN/dlogD size distribution vs. geometric mean diameter as calculated from the derivative of the cumulative mass loading curve fit. Recall that JOE2 is also the subroutine called by WALLY2 to plot a similar mass size distribution based on this derivative of the cumulative mass loading curve fit. The value of ISIG is the code input to JOE2 which allows this subroutine to distinguish which plot is desired - ISIG = 1 for dM/dlogD distribution and ISIG = 6 for dN/dlogD distribution. Only one set of data is represented on a plot for these calls to WALLY3 when ISIG = 6. After these points are plotted and the pen returned in readiness for the next plot, JOE2 returns to WALLY3. WALLY3 returns to mainline GRAPH to seek instructions for the next plot.

Subroutine JOE2--

This subroutine makes a plot of points from the dM/dlogD (if ISIG = 1) or dN/dlogD (if ISIS = 6) distribution in milligrams or number of particles per dry normal cubic meter vs. particle diameter in micrometers. This plot is based on the derivative of the fitted curve to cumulative mass loading vs. stage D_{50} for the given run and given assumed density. It also makes a listing on the line printer of diameter values in micrometers along with the corresponding differential size distribution value at that size.

028-038: Write the column headings at the top of the page on the line printer. These headings are "INTERVAL", "DIAMETER", and "CHANGE IN MASS CONCENTRATION (MG/DMN3)" or "CHANGE IN NUMBER CONCENTRATION (NO./DNM3)". The choice between the last two column headings is determined by the value of ISIG received by subroutine JOE2. If ISIG = 1, this subroutine plots points of the dM/dlogD distribution, and the former heading is printed. If ISIG = 6, this subroutine plots points of the dN/dlogD distribution, and the latter heading is printed.

039-050: A $\log_{10}$ diameter increment DINC is defined here. This is the amount by which the common log of the diameter is increased on each traverse of the loop in which the dM/dlogD or dN/dlogD distribution values are calculated. DINC is defined by dividing the difference in the common logs of 100.0 and 0.25 microns into 35 equal parts:

$$\text{DINC} = [\log_{10}(100.0) - \log_{10}(0.25)]/35$$

051: The first value of the independent variable, D1, to be used in calculating the size distribution value is defined here as the common log of an arbitrarily small particle size in micrometers.

Thus, the D1 value is initially defined as:

$$D1 = \log_{10}(0.25) \qquad (159)$$

052-053: Define the last value of the independent variable DLDF to be the maximum x-axis limit, XMAX. Recall that the x-axis (diameter) is a common log scale so that DLDF = XMAX is already in common log form.

054-057: Read record IS from file 11 (file FILSPL) containing the information for fitting $\log_{10}$ (cumulative mass loading) vs. $\log_{10}$ (D_{50}) for this run and assumed density. These variables are the number of interval boundary points which are fitted NPOIN, the values of these points $(X1,Y1)_I$, I = 1, NPOIN, and the series of fitting second degree polynomial coefficients $COE_{I,J}$, I = 1, INT, J = 1, 3, where INT is the number of fitted intervals, NPOIN-1.

058: A loop begins here and continues through statement 100 (card 145). The loop calculates the mass size distribution value or number size distribution value (depending on ISIG) at a given diameter. This is calculated according to the derivative of the second degree polynomial curve fit to the cumulative mass loading vs. diameter at this diameter as found in SPLIN1. Both graph and line printer output are produced in this loop.

059-063: DPLOT is the actual diameter in micrometers. This is the value output to the line printer. It is the result of taking the antilog of D1, the independent variable used in fitting:

$$DPLOT = 10.0^{D1} \qquad (160)$$

064-073: The "DO 320" loop here takes the diameter variable D1 and compares it to ever increasing X-coordinate values of the interval boundary points, (X1,Y1), fitted in program SPLIN1 to find the interval, NINT, containing D1.

074-082: The value of DELM, the mass size concentration at diameter DPLOT, is found here in milligrams per actual cubic meter. Mathematically this is:

$$\mathrm{DELM} = \frac{dM}{d(\log_{10}\mathrm{DPLOT})} \qquad (161)$$

where M = mass concentration in milligrams per actual cubic meter.

PPP, the cumulative mass loading fitting polynomial over a specified interval, NINT, is the common log of mass concentration as a function of D1, the common log of the diameter DPLOT:

$$\begin{aligned} \mathrm{PPP} &= \log_{10}M = f(\mathrm{D1}) = f(\log_{10}\mathrm{DPLOT}) \qquad (162) \\ &= \mathrm{COE}_{\mathrm{NINT},1}+\mathrm{COE}_{\mathrm{NINT},2}\mathrm{D1}+\mathrm{COE}_{\mathrm{NINT},3}(\mathrm{D1})^2 \end{aligned}$$

where $\mathrm{COE}_{\mathrm{NINT},J}$, J=1,3=fitting coefficients for for interval NINT which contains diameter DPLOT

This calculation of PPP is made at cards 079-081. Card 078 expresses DEL1, the derivative of this common log of cumulative mass concentration with respect to the common log of the diameter DPLOT:

$$\begin{aligned} \mathrm{DEL1} &= \frac{d\ \mathrm{PPP}}{d(\log_{10}\mathrm{DPLOT})} \qquad (163) \\ &= \frac{d(\log_{10}M)}{d(\log_{10}\mathrm{DPLOT})} \\ \mathrm{DEL1} &= \mathrm{COE}_{\mathrm{NINT},2}+2\mathrm{COE}_{\mathrm{NINT},3}\mathrm{D1} \end{aligned}$$

Using the following logic, DELM may be expressed in terms of PPP and DEL1:

$$\begin{aligned} \mathrm{DEL1} &= \frac{d\ \mathrm{PPP}}{d(\log_{10}\mathrm{DPLOT})} \qquad (164) \\ &= \frac{d(\log_{10}M)}{d(\log_{10}\mathrm{DPLOT})} \\ &= \frac{d(\log_{10}M)}{dM} \times \frac{dM}{d(\log_{10}\mathrm{DPLOT})} \end{aligned}$$

Then it follows that :

$$\mathrm{DELM} = \frac{dM}{d(\log_{10}\mathrm{DPLOT})} = \mathrm{DEL1} \times \frac{dM}{d(\log_{10}M)} \qquad (165)$$

To find $\frac{dM}{d(\log_{10}M)}$

$$M = \exp\ (\log_e M)$$

$$= \exp\ (\log_e 10 \times \log_{10}M) \qquad (166)$$

$$= \exp\ (2.30258\ \log_{10}M)$$

$$\frac{dM}{d(\log_{10}M)} = \frac{d}{d(\log_{10}M)}\ [\exp(2.302585\ \log_{10}M)] \qquad (167)$$

$$= 2.302585\ \exp\ (2.302585\ \log_{10}M) \qquad (168)$$

$$\frac{dM}{d(\log_{10}M)} = 2.302585\ M \qquad (169)$$

Then

$$\mathrm{DELM} = \mathrm{DEL1} \times 2.302585 \times 10^{\log_{10}M} \qquad (170)$$

or $$\mathrm{DELM} = \mathrm{DEL1} \times 2.302585 \times 10^{\mathrm{PPP}} \qquad (171)$$

This is the expression for DELM, the mass size concentration in milligrams per actual cubic meter, as calculated at card 082.

083-087: DELM as found above is in units of milligrams per actual cubic meter. The conversion of the differential mass size distribution to units of milligrams per dry normal cubic meter is dependent on the ambient pressure at the impactor inlet in atmospheres, POA, the temperature of the stack in degrees Kelvin, TKS, and the percent water content of the gas, FG_5: The conversion is calculated by:

$$\mathrm{DELM} = \mathrm{DELM}\frac{[(\mathrm{TKS}/294)(1/\mathrm{POA})]}{[(100-FG_5)/100]} \qquad (172)$$

088-092: The value of the dN/dlogD distribution at a given diameter in number of particles per dry normal cubic meter, DELN, can be expressed as a function of the value of the dM/dlogD distribution in milligrams per dry normal cubic meter, DELM, the density of the particles in grams per cubic centimeter, RHO, and the given particle diameter in micrometers, DPLOT. To show the development of this function, define the following variables:

v = volume of one particle in cubic micrometers,

m = mass of one particle in milligrams,

ρ = density of the particles in grams per cubic centimeter,

M = total mass of particles in one cubic meter in grams,

N = total number of particles in one cubic meter, and,

DPLOT = particle diameter in micrometers.

The mathematical expressions for v, m, and M are:

$$v = \frac{\pi(\text{DPLOT})^3}{6} \ (\mu\text{m}^3)$$

$$m = \rho\left(\frac{\text{gm}}{\text{cm}^3}\right) \times 10^3\left(\frac{\text{mg}}{\text{gm}}\right) \times \frac{\pi(\text{DPLOT})^3}{6} \ (\mu\text{m}^3) \times \left(10^{-4}\frac{\text{cm}}{\mu\text{m}}\right)^3$$

$$m = \frac{\rho\pi(\text{DPLOT})^3}{6} \times 10^{-9}(\text{mg.})$$

$$M = Nm \ (\text{mg.})$$

Then DELN or $\frac{dN}{d(\log_{10}\text{DPLOT})}$ may be expressed as a function of DELM, ρ, and DPLOT:

$$\text{DELM} = \frac{dM}{d(\log_{10}\text{DPLOT})} = \frac{d(Nm)}{d(\log_{10}\text{DPLOT})} \qquad (173)$$

$$= m\frac{dN}{d(\log_{10}\text{DPLOT})} \qquad (174)$$

Then

$$\frac{dN}{d(\log_{10}\text{DPLOT})} = \frac{dM}{d(\log_{10}\text{DPLOT})} \times \frac{1}{m} \qquad (175)$$

$$= \frac{\text{DELM}}{m} \qquad (176)$$

or $$\frac{dN}{d(\log_{10}DPLOT)} = DELM\frac{6}{\rho\pi(DPLOT)^3} \times 10^9 \text{ (number of particles per dry normal cubic meter)} \tag{177}$$

which is the expression used in defining dN/dlogD at card 102, where the program name is DELN.

093-098: Define the change in concentration as DEL. If ISIG = 1 this refers to dM/dlogD, DELM, in milligrams per dry normal cubic meter. If ISIG = 6 this refers to dN/dlogD, DELN, in number of particles per dry normal cubic meter.

099-111: If the cumulative mass loading fitting function is always increasing, as it should, the change in concentration, DEL, will be positive. Then the common log of DEL can be taken at statement 65 (card 111). If, however, there are some points within the plotting range where the function is non-increasing, the $\log_{10}$ of the resulting zero or negative DEL value cannot be taken. In this case, instead of taking the true $\log_{10}$ value of DEL, it is given the arbitrary extremely low $\log_{10}$ value of -50.0 at statement 60 (card 106). This will later be seen as a signal of undesirable function behavior in the line printer output.

112-120: This section uses the functions XVAL and YVAL to check the values of the $\log_{10}$ of diameter, D1, and the $\log_{10}$ of change in concentration, DEL, for values which would cause the plotter to plot outside the limits of the graph (e.g., if DEL = -50.0). It assigns to any such extreme coordinate a value which causes the point to be plotted 0.15 inches beyond the exceeded boundary. The call to plotter subroutine FPLOT(-2, XN, YN) moves the pen to the new point location (XN, YN) and lowers it. The pen is in the up position when this is called. The call to plotter subroutine SYMBOL (9, 0.04) causes the symbol of a solid circle 0.04 inches in diameter to be drawn. Finally the pen is raised in preparation for the next pen movement by FPLOT (+1, XN, YN).

121: This statement causes the program to omit converting the $\log_{10}$ of the change in concentration if the former value = -50.0. Finding the antilog here would serve no purpose since -50.0 has no true meaning except as a signal to mark undesirable function behavior.

122-125: For proper values of $\log_{10}$ of change in concentration, the antilog is taken. This yields the original change in concentration value, DEL, which will be printed:

$$\mathrm{DEL} = 10.0^{\mathrm{DEL}}$$

126-131: Write under the proper column heading the "slot number" I which is a diameter index or point index, the diameter in micrometers, DPLOT, and the change in mass concentration (if ISIG = 1) or the change in number concentration (if ISIG = 6), DEL.

132-137: If the function shows non-increasing change in concentration, this write statement takes the place of the one at card 130. The program writes under the proper column heading the diameter index, the diameter in micrometers, DPLOT, and "NON-INCREASING."

138-145: The common log diameter value is compared with XMAX which is the maximum x-axis limit, a common log of the scale value. If D1 is larger than this value, the plotting diameter range has been covered, and the program exits the loop. If D1 is not greater than XMAX, it is incremented by DINC. Recall that D1 is the independent variable for the fitting equation, $\log_{10}$ (diameter). The program then returns to the top of the loop at card 058 to calculate $\log_{10}$ (dM/dlogD) or $\log_{10}$ (dN/dlogD) for this next D1.

146-154: The pen is returned to the base line in the up position, 4.5 inches beyond the maximum x-axis limit, XMAX, so that it is now ready for the next plot. The subroutine now returns to the calling subroutine WALLY2 (if ISIG = 1) or WALLY3 (if ISIG = 6).

Input and Output for the Mainline Program GRAPH

Card Input and Resulting Output--

Card A--Data punched on this card determine whether the cycles shown on the $\log_{10}$ axes of each plot will be of a standard range and number or if this range and number will be regulated by the span of the data. This coding has no bearing, however, on the 'cycles' shown on normal probability axes used in the graph of cumulative percent mass loading vs. particle diameter in micrometers. Also, this card coding indicates whether plotting code values (see cards B and C below) are to be read once and used for all data sets, or whether new plotting code values are to be read for each run.

Column 1: Punch "0" or leave blank if the standard range and number of cycles are desired for all plots of cumulative mass loading in milligrams per actual cubic meter vs. particle diameter in micrometers. The standard maximum and minimum cumulative mass loading (Y) and particle diameter (X) axis limits are as follows:

$$XMAX = \log_{10}(100) = 2 \quad (178)$$

$$YMAX = \log_{10}(10^4) = 4 \quad (179)$$

$$XMIN = \log_{10}(10^{-1}) = -1 \quad (180)$$

$$YMIN = \log_{10}(10^{-1}) = -1 \quad (181)$$

Punch a "1" here if it is desired to regulate the range and number of cycles of cumulative mass loading plots according to the data. The maximum axis limit for particle diameter is still standard:

$$XMAX = \log_{10}(100) = 2 \quad (182)$$

The other axis limits are found by the function SLIM(MAXMIN,ALIMIT). SLIM truncates ALIMIT to the next smaller integer value if MAXMIN = 0. SLIM rounds up ALIMIT to the next higher integer if MAXMIN = 1. Thus:

$$XMIN = SLIM\ (0,\log_{10}DPMIN_N) \quad (183)$$

$$YMAX = SLIM\ (1,\log_{10}CUMAX_N) \quad (184)$$

$$YMIN = SLIM\ (0,\log_{10}CUMIN_N) \quad (185)$$

$DPMIN_N$ is the smallest lower size limit diameter, in micrometers, of all the runs at the desired density. When N = 1, $DPMIN_1$ is this lower limit assuming physical density. When N = 2, $DPMIN_2$ is this minimum assuming unit density. $CUMAX_N$ is the largest total mass loading value, in milligrams per actual cubic meter, of all the runs at the density indicated by the value of N, as described above.

$CUMIN_N$ is the smallest cumulative mass loading value, in milligrams per actual meter, of all the runs at the density indicated by the value of N as described above.

Column 2: Punch "0" or leave blank if the standard range and number of cycles are desired for all plots of $\Delta M/\Delta \log D$ or $dM/d\log D$ in milligrams per dry normal cubic meter vs. geometric mean diameter of particles at that stage in micrometers. The standard maximum and minimum size distribution on mass basis (Y) and geometric mean diameter (X) axis limits depend upon the impactor used. For the Andersen, University of Washington Mark III (Pilat), and Meteorology Research, Inc., impactors, these standard limits are:

$$\mathrm{XMAX} = \log_{10}(10^2) = 2 \tag{186}$$

$$\mathrm{YMAX} = \log_{10}(10^4) = 4 \tag{187}$$

$$\mathrm{XMIN} = \log_{10}(10^{-1}) = -1 \tag{188}$$

$$\mathrm{YMIN} = \log_{10}(10^{-2}) = -2 \tag{189}$$

For the Brink impactor, these limits are:

$$\mathrm{XMAX} = \log_{10}(10^2) = 2 \tag{190}$$

$$\mathrm{YMAX} = \log_{10}(10^6) = 6 \tag{191}$$

$$\mathrm{XMIN} = \log_{10}(10^{-1}) = -1 \tag{192}$$

$$\mathrm{YMIN} = \log_{10}(1) = 0 \tag{193}$$

Punch a "1" here if it is desired to regulate the range and number of cycles for plots of $\Delta M/\Delta \log D$ or $dM/d\log D$ according to the data. The maximum axis limit for geometric mean diameter is still standard.

$$\mathrm{XMAX} = \log_{10}(10^2) = 2 \tag{194}$$

The other axis limits are found by the function SLIM(MAXMIN,ALIMIT). SLIM truncates the value of ALIMIT to the next lower integer if MAXMIN = 0. SLIM rounds up the value of ALIMIT to the next higher integer if MAXMIN = 1. Thus:

$$\mathrm{XMIN} = \mathrm{SLIM}\ (0, \log_{10}\mathrm{GDMIN}_N) \tag{195}$$

$$\mathrm{YMAX} = \mathrm{SLIM}\ (1, \log_{10}\mathrm{DMMAX}_N) \tag{196}$$

$$\mathrm{YMIN} = \mathrm{SLIM}\ (0, \log_{10}\mathrm{DMMIN}_N) \tag{197}$$

$GDMIN_N$ is the smallest geometric mean diameter, in micrometers, of all the runs at the desired density. When N = 1, $GDMIN_1$ is this minimum geometric mean diameter assuming, physical density. When N = 2, $GDMIN_2$ is this minimum, assuming unit density. $DMMAX_N$ is the largest ΔM/ΔlogD or dM/dlogD value in milligrams per dry normal cubic meter of all the runs at the desired density (indicated by the value of N as described above). $DMMIN_N$ is the smallest ΔM/ΔlogD or dM/dlogD value in milligrams per dry normal cubic meter of all the runs at the desired density (indicated by the value of N as described above).

Column 3: Punch "0" or leave blank if the standard range and number of cycles are desired for all plots of ΔN/ΔlogD or dN/dlogD in number of particles per dry normal cubic meter vs. geometric mean diameter of particles at that stage in micrometers. The standard maximum and minimum ΔN/ΔlogD or dN/dlogD (Y) and geometric mean diameter (X) axes limits depend upon the impactor used. For the Andersen, University of Washington Mark III (Pilat), and Meteorology Research, Inc., impactors, these standard limits are:

$$XMAX = \log_{10}(100) = 2 \quad (198)$$

$$YMAX = \log_{10}(10^{15}) = 15 \quad (199)$$

$$XMIN = \log_{10}(10^{-1}) = -1 \quad (200)$$

$$YMIN = \log_{10}(10^{6}) = 6 \quad (201)$$

For the Brink impactor, these limits are:

$$XMAX = \log_{10}(100) = 2 \quad (202)$$

$$YMAX = \log_{10}(10^{14}) = 14 \quad (203)$$

$$XMIN = \log_{10}(10^{-1}) = -1 \quad (204)$$

$$YMIN = \log_{10}(10^{5}) = 5 \quad (205)$$

Punch a "1" here if it is desired to regulate the range and number of cycles for plots of $\Delta N/\Delta \log D$ or $dN/d\log D$ according to the data. XMAX and XMIN are based on the maximum and minimum geometric mean diameter values in micrometers, $GDMAX_N$ and $GDMIN_N$. They are the same as described in the section for "Column 2" above. The vertical axis limits are as follows:

$$YMAX = SLIM(1,\log_{10}DNMAX_N) \qquad (206)$$
$$YMIN = SLIM(0,\log_{10}DNMIN_N)$$

$DNMAX_N$ is the largest $\Delta N/\Delta \log D$ or $dN/d\log D$ value in number of particles per dry normal cubic meter of all the runs at the desired density. When $N = 1$, $DNMAX_1$ is this maximum assuming physical density. When $N = 2$, $DNMAX_2$ is this maximum, assuming unit density. $DNMIN_N$ is the smallest $\Delta N/\Delta \log D$ or $dN/d\log D$ value in number of particles per dry normal cubic meter of all the runs at the desired density (indicated by the value of N as described above).

Column 4: Punch "0" here or leave blank if plotting code values (see cards B and C below) are to be read once. In this case the plotting instructions for all runs are read from a single card B and a single card C. Punch "1" here if plotting code values are to be read for each set of data. In this case there would be as many B and C cards as there are number of impactor runs for which there are sets of data, NRUN.

Card B--This card contains the values of plotting code variables for the "raw data" plots. These are referred to as "raw data" plots because they are based on the mass captured at each stage. There is a code variable providing the option to superimpose two or more data sets on one graph or to show each set of data on a separate graph. The plotting choices are:

a) cumulative mass loading less than each stage D_{50}, in milligrams per actual cubic meter $CUMG_I$, I = 1, 8 (and the total mass loading in the same units, GRNAM) vs. the lower size limit of particles on that stage, in micrometers, DMAX

b) $\Delta M/\Delta \log D$ in milligrams per dry normal cubic meter, $DMDLD_I$, I = 1, 9, vs. geometric mean diameter of all particles on the stage in micrometers, $GEOMD_I$, I = 1, 9

c) $\Delta N/\Delta \log D$ in number of particles per dry normal cubic meter $DNDLD_I$, I = 1, 9, vs. the geometric mean diameter of all particles on the stage in micrometers, $GEOMD_I$, I = 1, 9.

There are actually two possible plots for each of the three described above since separate calculations are made for physical density and unit density.

The plots which may be obtained are discussed below. Note that a value of "0" produces the plot desired while a value of "1" suppresses the plot.

Column 1: Leave this column blank or punch a "0" if it is desired to superimpose the raw data points of this run on the same grid as that used by the previous run. Up to a maximum of 9 sets of data may be superimposed on one grid, each set of data plotted with a different symbol. Punch a positive number in this field, e.g. "1", to draw a new grid for each plot requested for this run. The first card in card position B must have a positive number punched in this field since there is no grid available from a "previous" plot.

Column 2: Punch "0" to receive a graph of cumulative mass loading below each stage in milligrams per actual cubic meter, CUMG, and the total mass loading in the same units, GRNAM, vs. the lower size limit of particles on that stage in micrometers, DPC, and the maximum particle diameter in the same units, DMAX. Unit density, 1.0 gram per cubic centimeter is assumed. The graph also shows a secondary vertical axis to the right with cumulative mass loading in grams per actual cubic foot. Punch "1" in column 2 to suppress the graph.

Column 3: Punch "0" to receive a graph of $\Delta M/\Delta \log D$ in milligrams per dry normal cubic meter, DMDLD, vs. the geometric mean diameter of particles captured on the I^{th} stage $GEOMD_I$ assuming unit density, 1.0 gram per cubic centimeter. Punch "1" in column 3 to suppress the graph.

Column 4: Punch "0" to receive a graph of $\Delta N/\Delta \log D$ in number of particles per dry normal cubic meter DNDLD vs. geometric mean diameter of particles captured on the I^{th} stage, $GEOMD_I$, assuming unit density, 1.0 gram per cubic centimeter. Punch "1" in column 4 to suppress the graph.

Column 5: Punch "0" to receive the same graph as described for Column 2 of this card except here the plotted point values are found by assuming physical density. Punch "1" to suppress the graph.

Column 6: Punch "0" to receive the same graph as described for Column 3 of this card except here the plotted point values are found by assuming physical density. Punch "1" to suppress the graph.

Column 7: Punch "0" to receive the same graph as described for Column 4 of this card except here the plotted point values are found by assuming physical density. Punch "1" to suppress the graph.

Card C--This card contains the values of plotting code variables to obtain plots for fitted data plots. For each plot required, there must be a record of the series of fitting polynomials for these data present on file FILSPL (file 11). Therefore, mainline program SPLIN1, in addition to mainline program MPPROG, must be run previously before any of the following plots can be obtained. The plot choices showing the results of curve fitting are:

a) cumulative mass loading of particulate less than indicated diameter in milligrams per actual cubic meter vs. particle diameter in micrometers

b) cumulative percent mass loading of particulate less than indicated diameter vs. particle diameter in micrometers

c) dM/dlogD in milligrams per dry normal cubic meter vs. geometric mean diameter of the size interval in micrometers

d) dN/dlogD in number of particles per dry normal meter vs. geometric mean diameter of the size interval in micrometers.

There are, again, two possible plots for each of the four described above since there are separate calculations made for physical density and unit density. Except for the cumulative percent plots, each of the plots described above show the "raw data" points (as described for Card B) superimposed on the fitted data. To show more than one run of data on any one of these graphs would create a cluttered and confusing plot. Therefore, there is no option to superimpose more than one set of data on a graph, as there was for those plots controlled by Card B.

For each plot of the type b, c, or d described above, there is other output in addition to the graph. This consists of a line printer table of plotted values. The plots which can be selected on card C are discussed below. Again, note that "0" produces the plot while "1" suppresses the plot.

Column 1: Punch "0" to receive the curve of cumulative mass loading of particulate less than indicated diameter, in milligrams per actual cubic meter, vs. particle diameter, in micrometers, according to the predetermined fitting equation where unit density is assumed. The graph also shows the points on which the curve fit was based. These latter points are the same data as plotted according to Card E, Column 2. Punch "1" to suppress the graph.

Column 2: Punch "0" to receive the line printer table and graph of cumulative percent of total mass loading for particulate less than the indicated diameter vs. particle diameter in micrometers where unit density is assumed. Punch "1" to suppress the graph.

Column 3: Punch "0" to receive the line printer table and graph of $dM/d\log D$ in milligrams per dry normal cubic meter vs. particle diameter in micrometers as determined from the derivative of the predetermined fitting equation assuming unit density. The graph also shows the $\Delta M/\Delta \log D$ distribution obtained from the particulate matter collected at each stage. These latter points are the same data as plotted according to Card E, Column 3. Punch "1" to suppress the graph.

Column 4: Punch "0" to get the line printer table and graph of $dN/d\log D$ in number of particles per dry normal cubic meter vs. particle diameter in micrometers as determined from the derivative of the predetermined fitting equation assuming unit density. The graph also shows the $\Delta N/\Delta \log D$ distribution obtained from the particulate matter collected at each stage. These latter points are the same data as plotted according to Card E, Column 4. Punch "1" to suppress the graph.

Column 5: Punch "0" to receive the same graph as described for Column 1 of this card except here the plotted values are found by assuming physical density. Punch "1" to suppress the graph.

Column 6: Punch "0" to receive the same table and graph as described for Column 2 of this card except here the values are found by assuming physical density. Punch "1" to suppress the table and graph.

Column 7: Punch "0" to receive the same table and graph as described for Column 3 of this card except here the values are found by assuming physical density. Punch "1" to suppress the table and graph.

Column 8: Punch "0" to receive the same table and graph as described for Column 4 of this card except here the values are found by assuming physical density. Punch "1" to suppress the table and graph.

File Input and Output--

Program GRAPH uses three random access files. One of these, file number 8 under the file name "GRAPHO", is used exclusively within this program. All input into this file is made within this program and the only reading of file 8 takes place within this program. This file is discussed in further detail below. File 10, under the file name "KMC001", carries needed information for programs SPLIN2 and GRAPH from the running of the impactor program MPPROG. File 10 is only a source of input data for program GRAPH. No additional values are added to it by this program. The third file is file number 11 with the file name "FILSPL". It carries the fitting coefficients for fits made to $\log_{10}$ (cumulative mass loading) vs. $\log_{10}(D_{50})$ for each run and assumed density. Two records are kept for each run as in file 10: one for assumed physical density and one for unit density.

File number 8, referenced as "FGRAPH" under the file name "GRAPH", is used to store the plotting code values for each run as input from cards. There are a total of 50 records, each allocated 15 words. Each of these records contains the plotting code values for one impactor run. These include the values for obtaining both physical density plots and unit density plots. This is unlike files 10 and 11 where there are two records for each impactor run: one for data obtained assuming physical density and one for data obtained assuming unit density. Each variable is an integer requiring one word. The variables and their definitions are as follows:

MPLOT: The value is 0 if a new grid is desired for plotting data from this impactor run. The value is 1 if data from this impactor run are to be superimposed on the graph of a previous run(s).

J1: The value is 0 if the plot of cumulative mass loading less than stage D_{50} in milligrams per actual cubic meter vs. stage D_{50} in micrometers is desired for assumed unit density. The value is 1 if this plot is to be suppressed.

J2: The value is 0 if the plot of $\Delta M/\Delta \log D$ in milligrams per dry normal cubic meter vs. geometric mean diameter in micrometers of each stage in micrometers is desired for assumed unit density. The value is 1 if this plot is to be suppressed.

J3: The value is 0 if the plot of $\Delta N/\Delta \log D$ in number of particles per dry normal cubic meter vs. geometric mean diameter in micrometers of each stage in micrometers is desired for assumed density. The value is 1 if this plot is to be suppressed.

J4: The value is 0 to obtain the same plot as given for J1 = 0 except that physical density is assumed. The value is 1 if this plot is to be suppressed.

J5: The value is 0 to obtain the same plot as given for J2 = 0 except that physical density is assumed. The value is 1 if this plot is to be suppressed.

J6: The value is 0 to obtain the same plot as given for J3 = 0 except that physical density is assumed. The value is 1 if this plot is to be suppressed.

JP1: The value is 0 to obtain the same plot as for J1 = 0 with the fitted curve to these data superimposed. The value is 1 if this plot is to be suppressed.

JPCNT1: The value is 0 to obtain the curve of cumulative percent mass loading vs. particle diameter in micrometers as determined from the cumulative mass loading vs. D_{50} curve fit assuming density. The value is 1 if this plot is to be suppressed.

JP2: The value is 0 to obtain the same plot as for J2 = 0 with points of the dM/dlogD distribution superimposed. This dM/dlogD distribution is obtained from the derivative with respect to $\log_{10}$ (diameter) of the cumulative mass loading vs. D_{50} curve fit. The value is 1 if this plot is to be suppressed.

JP3: The value is 0 to obtain the same plot as for J3 = 0 with points of the dN/dlogD distribution superimposed. Again this is obtained from the derivative of the cumulative mass loading curve fit. The value is 1 if this plot is to be suppressed.

JP4: The value is 0 to obtain the same plot as for J1 = 0 except that physical density is assumed and the fitted curve to this data is also superimposed. The value is 1 if this plot is to be suppressed.

JPCNT4: The value is 0 to obtain the curve of cumulative percent mass loading vs. particle diameter, in micrometers, for assumed physical density as determined from the cumulative mass loading vs. D_{50} curve fit. The value is 1 if this plot is to be suppressed.

JP5: The value is 0 to obtain the same plot as for J2 = 0 except that physical density is assumed and the points of the dM/dlogD distribution are superimposed. This dM/dlogD distribution is obtained from the derivative with respect to $\log_{10}$ diameter of the cumulative mass loading vs. D_{50} curve fit. The value is 1 if this plot is to be suppressed.

JP6: The value is 0 to obtain the same plot as for J3 = 0 except that physical density is assumed and the points of the dN/dlogD distribution are superimposed. Again this is obtained from the derivative of the cumulative mass loading curve fit. The value is 1 if this plot is to be suppressed.

PROGRAM STATIS

The program STATIS is designed to make statistical analyses of the data taken during a number of impactor runs for a given test situation.

The user may obtain the following results in both tabular and graphical form:

a. average cumulative mass loading less than indicated diameter in milligrams per actual cubic meter
b. average percent cumulative mass loading less than indicated diameter
c. average differential particle-size distribution on a mass basis in milligrams per dry normal cubic meter (dM/dlogD)
d. average differential particle-size distribution on a number basis in number of particles per dry normal cubic meter (dN/dlogD).

Also calculated for each of these are the 50% confidence limits. (Note: These may be changed to 90% confidence limits by replacing the equations as indicated in this write-up.) Averages and confidence limits are based on the exclusion of outliers. Outliers are defined as any data not within a certain interval of the original average (including all data). See the discussion of subroutine AVCON for the specific definition of outlying data used in this program. Each of the four types of analysis discussed here is made for data where physical particle density is assumed and where unit density is assumed.

The programs which must be run before the execution of STATIS are the impactor program MPPROG and the cumulative mass loading vs. diameter fitting program, SPLIN1. The impactor program stores the data points for cumulative mass loading vs. stage D_{50} for each of the impactor runs, and the fitting program fits each of these sets of data with a series of overlapping, continuous, second degree polynomials. The parameters for each curve fit (number of intervals, interval boundaries, and coefficient values) must be on file so that they may be used in program STATIS to regenerate the cumulative mass loading vs. diameter curve fit for each impactor run. From this, one may generate a cumulative percent loading curve. With the original fitting equation and its derivative, the dM/dlogD and dN/dlogD graphs may also be generated. Thus, all calculations to obtain averages in STATIS are based on information derived from cumulative mass loading vs. D_{50} curve fits for individual impactor runs stored by the fitting program SPLIN1.

The execution of program STATIS is also essential to the execution of program PENTRA which is used to calculate the penetration and efficiency of the gas cleaning device versus particle size. PENTRA uses the magnitude of average dM/dlogD values at the indicated diameters, and standard deviation about the average stored on file by STATIS, in order to make the penetration and efficiency calculations. STATIS must actually be executed twice—once each for the inlet and outlet data sets.

It should be noted that in the Breakdown of Program STATIS below, physical density is assumed to have been input to program MPPROG. This results in calculations based on physical density and unit density (definition of aerodynamic diameter user specified) being listed alternately in output files. The user may instead desire to input only unit density to MPPROG yielding calculations based on the two different definitions of aerodynamic diameter (Mercer's[2] and Task Group on Lung Dynamics[1]).

Breakdown of Program STATIS

038-046: Read coding to indicate whether the data to be used are inlet or outlet information. Consequently, the proper sequential file is established for output from this program. If statistical calculations are being made for inlet data, the information is stored in file 16; if statistical calculations are being made for outlet data, the information is stored in file 17.

047-073: Read coding to indicate whether even or odd numbered records are to be used for averaging (i.e., whether records for physical density, respectively, are to be used, which plots are desired, the plotting range for these plots, and whether a constant of integration is to be added to calculation of average cumulative mass loading. The coding NOFILE = 1 is the indication that there have been no fits made to the cumulative mass loading vs. D_{50} for this density. Thus, no statistical calculations are to be made for the data of this assumed density. The program enters "flag" variable values which will indicate that penetration—efficiency calculations cannot be made for this density when read in program PENTRA. These dM/dlogD values are "0"'s where the assumed density and number of diameter points examined would have been entered. For example, if N = 1 and NOFILE = 1, the assumed density is physical, and the program returns to statement number 1 (card 067) to read in information concerning unit density (N = 2). If N is 2 and NOFILE = 1, the program ends with the STOP command.

074-087: A desired maximum plotted diameter may be read into the program. Otherwise, the maximum plotted diameter is 8.0 micrometers (PSTOP) for physical density and 10.0 micrometers (ASTOP) for unit density.

088-118: Read the general information record (record 101) from file 10. This includes the number of impactor runs, NRUN, coding for the type of impactor, IMPAC, the general identification label, IDALL, physical density, RHO1, and grid limits for all plots according to the range of the data, GEMAX through CUMIN.

119-124: The assumed particle density for these statistical calculations is saved as RHOX. This is the physical density RHO1 read from the general information record 101 if N = 1. RHOX is the unit density 1.0 gram per cubic centimeter if N = 2.

125-129: The last record containing run data for the assumed density is defined here as ISFIN according to the assumed density as indicated by coding N and according to the number of impactor runs to be statistically evaluated, NRUN. (Recall, there are two records for each impactor run—odd records for assumed physical density, even records for assumed unit density.

130: The average total mass (grain) loading for this assumed density, $ATGL_N$, is given an initial value of 0.0 milligram per actual cubic meter before its calculation.

131-137: In a loop, the total mass loading, TGL_{IS} in milligrams per actual cubic meter, is read from file 10 for each run.

138-150: IAVLD is coding in subroutine AVCON to indicate whether confidence limits are to be found for averages. It is set equal to 0 here so that confidence limits are not calculated for the average total mass loading, $ATGL_{IS}$. The subroutine AVCON (N, IAVLD, NDK, $NOCON_1$, ISFIN, TGL, $ATGL_N$, AVDM1, $CUM2D_1$, CUM2LD, CISUM, SIGMA, CLU_1, CLL_1, DINC) takes the total mass loading values, TGL, to calculate a preliminary standard deviation SIGMA. A new final average $ATGL_N$ is then calculated where any outlying TGL_{IS} values are excluded. The variables $NOCON_1$ and AVDM1 through DINC are dummy variables in this case. No confidence limits are taken.

151-158: $CUM2D_1$ is the cumulative mass loading less than the specified diameter in milligrams per actual cubic meter; CUM2LD is this same quantity up to the previous diameter. CISUM is the sum of the squares of the confidence intervals of all the dM/dlogD values up to the specified diameter in milligrams per actual cubic meter. AVDML is the average dM/dlogD value at the previous specified diameter in milligrams per actual cubic meter. At this time, before entering the loop at card 153, there are no "specified" diameters. Thus, $CUM2D_1$, CUM2LD, CISUM, and AVDM1, are given initial values of 0.0 here.

159-627: The program begins a large loop here through statement 254 (card 627). The index MDK (or NDK = MDK - 2) specifies the type of calculations and output to be made on each passage through the loop:

MDK = 1 or NDK = -1 yields graph and line printer output for average cumulative mass loading less than specified diameter in milligrams per actual cubic meter vs. specified diameter in micrometers. Also on this same traverse NDK1 is changed from 0 to 1 to obtain the same output for cumulative percent mass loading less than specified diameter vs. specified diameter in micrometers.

MDK = 2 or NDK = 0 yields graph, line printer, and file output for average dM/dlogD in milligrams per dry normal cubic meter vs. specified diameter in micrometers.

MDK = 3 or NDK = 1 yields graph and line printer output for average dN/dlogD in number of particles per dry normal cubic meter vs. specified diameter in micrometers.

All of the output discussed here also includes upper and lower 50% confidence limits. (Note: 90% confidence limits may be obtained by substituting the formulas as specified in the discussion of subroutine AVCON.) Also, a list of outlying values is printed with each type of calculation.

188: NDK1 is a code variable whose value determines the type of vertical scale desired for plotting.
NDK1 = 0 yields a common log vertical scale.
NDK1 = 1 yields a log probability scale (used only for plotting of average cumulative percent mass loading).

189-245: According to the type of calculations to be made, i.e., according to the value of MDK, various headings are written at the top of the page on the line printer. The heading always includes the general identification label IDALL and assumed density RHOX. For MDK = 1 there are column headings for diameter index number, diameter in micrometers, mean cumulative mass concentration less than specified diameter in milligrams per actual cubic meter, and upper and lower 50% confidence limits in the same units. For MDK = 2 there are column headings for diameter index number, diameter (micrometers), mean dM/dlogD in milligrams per dry normal cubic meter, standard deviation, and upper and lower 50% confidence limits all in the same units. Likewise, for MDK = 3 there are the same headings for dN/dlogD in number of particles per dry normal cubic meter. Also if a plot is desired (when IPLT1, IPLT2, or IPLT3 = 0 for MDK = 1, 2, or 3, respectively) a plotting grid is drawn on the plotter by subroutine STPLOT along with labeling of axes.

246-255: Define the common log increment of the diameter to be added on each traverse of the loop, DINC. For calculations of cumulative mass loading, DINC is defined such that there are 28 points per common log cycle:

$$\text{DINC} = 0.0357142857 \tag{208}$$

For calculation of dM/dlogD and dN/dlogD, DINC is defined such that there are 14 points per common log cycle:

$$\text{DINC} = 0.0714285714 \tag{209}$$

The number of points per log cycle is arbitrary; however, the number of points for cumulative mass loading is twice that of the differential size distributions in order to construct a more accurate cumulative mass loading curve. (The ultimate would be an infinite number of changes in mass concentration summed over infinitely small $\log_{10}$ diameter intervals.)

256-261: D1 is the variable used in the derivative fitting equation and is defined as the common logarithm of the true particle diameter in micrometers. The curve fit starts at 0.25 micrometers diameter. This is an arbitrarily chosen size with which to begin the fitting loop. The user should take appropriate caution in evaluating extrapolated data if the D_{50} or geometric mean diameter of the last stage is greater than this beginning particle size of 0.25 micrometers. The initial value of D1 is:

$$\text{D1} = \log_{10}(0.25) \tag{210}$$

262-272: The maximum diameter at which calculations cease, DSTOP, is defined in micrometers according to the assumed particle density. (Recall discussion of cards 074-087 that this maximum diameter is ASTOP for assumed unit physical density.)

273-274: The number of points (diameters) at which calculations are to be made, PLAS, is defined by dividing the plotting range by the common log increment DINC:

$$\mathrm{PLAS} = [\log_{10}(\mathrm{DSTOP}) - \mathrm{D1}]/\mathrm{DINC} \quad (211)$$

This real variable PLAS is changed to an integer variable LAS with one point added for the initial point D1:

$$\mathrm{LAS} = \mathrm{PLAS} + 1 \quad (212)$$

275-279: If calculations are being made for the mean dM/dlogD size distribution (NDK = 0), the first entry into a sequential file MPACFL is made here. MPACFL = 16 if the data here is from inlet testing. MPACFL = 17 if this data is from outlet testing. (See discussion on cards 038-046). The information from this file along with information from the companion inlet or outlet file will be used in program PENTRA to calculate penetration and efficiency of the gas cleaning device. This first entry consists of assumed particle density, RHOX, in grams per cubic centimeter, and the number of tested diameter points, LAS.

280-485: A loop begins here which contains all calculations to obtain average cumulative mass loading (NDK = -1), average dM/dlogD (NDK = 0), or average dN/dlogD (NDK = -1) vs. particle diameter with 50% confidence limits. Output to the line printer, plotter, and file MPACFL (for NDK = 0) are also made in this loop. The value of NSLOT is the diameter index number and MSLOT = NSLOT -1 is the diameter index number of the previous diameter. Note that the average percent cumulative mass concentration vs. particle diameter is calculated outside the loop.

291-295: DPLOT is the actual diameter in micrometers, and is a function of the curve fitting diameter variable D1:

$$DPLOT = 10.0^{D1} \qquad (213)$$

296-303: A sum of changes in particle concentration, SUM, is calculated over all runs at the indicated diameter, DPLOT. This is the sum of changes on a mass basis in milligrams per actual cubic meter if NDK = -1, or the sum of changes on a mass basis in milligrams per dry normal cubic meter if NDK = 0, or the sum of changes on a number basis in number of particles per dry normal cubic meter if NDK = 1. SUM is given the initial value of 0.0, and the number of runs contributing a quantity to this sum, NUPTS, is also given an initial value of 0.

304-377: The loop begins here which sums the increments as discussed above. Note that the index IAV is incremented by 2 on each traverse of the loop so that only those records having the same assumed density provide data to be summed.

305-311: The record of each run for the assumed density is read to obtain the stack temperature in degrees Kelvin, TKS, the impactor inlet pressure in atmospheres, POA, and the percent water-vapor content of the gas, FGH2O. These are used to convert average mass size distribution values from milligram per actual cubic meter to milligrams per dry normal cubic meter. (See cards 357-364.) Variables NFIT, GRNAM, ID, and RHO are dummy variables here.

312-321: At the appropriate record IS, the number of interval boundary points generated for the cumulative mass loading fit, NPOIN, is read. The number of intervals which these points bound, INT, is defined as NPOIN -1. From this record, the program also reads the actual boundary point values, Xl_I (I=1,NPOIN) and Yl_I (I=1,NPOIN), and the second degree polynomial coefficients which yield the curve fit to the cumulative mass loading vs. D_{50} data for the run, COE_{IJ} (I=1,INT; J=1,3).

322-330: The diameter variable Dl is tested in a loop to find the interval in which it lies. Starting at the second smallest boundary diameter variable Xl_2, Dl is compared to the boundary diameter variable values until $Dl \leq Xl_J$. Then the interval, NINT, in which Dl lies is equal to J -1. If there are Dl values $< Xl_1$ (which is $\log_{10}(D_{50})$ of the smallest stage cutpoint), they are defined as being in the first interval NINT = 1. If there are Dl values $> Xl_{NPOIN}$, which is $\log_{10}$ (maximum particle diameter), they are defined as being in the last interval NINT.

331-343: If average cumulative mass loading is being calculated (NDK= -1), and if this is the first traverse of the loop (NSLCT=1, i.e., finding the cumulative mass loading of particulate < 0.25 micrometers), and if a cumulative mass loading constant of integration is desired (NCUCON=0), this constant is calculated for each run of this assumed density, $CUCONl_{IS}$, as a function of the diameter variable with a value one increment smaller (DINC) than the first value of $Dl = \log_{10}(0.25)$:

$$CUCONl_{IS} = C_1 + C_2(Dl-DINC) + C_3(Dl-DINC)^2 \quad (214)$$

The value $CUCON_1$ found here is in the form of the $\log_{10}$ (cumulative mass loading). The antilog is taken so that CUCONl is actual cumulative mass loading up to but not including 0.25 micrometers. Note also that if this "initial" cumulative mass loading is $< 10^{-5}$ milligrams per actual cubic meter, it is given that value anyway. This is to prevent such a large range of scale for the average cumulative mass loading grid.

344-357: The program calculates the change in mass concentration with respect to $\log_{10}$ (diameter), dM/dlogD, in milligrams per actual cubic meter at the given diameter. This requires both the value of $\log_{10}$ (cumulative mass concentration), PPP, as determined by the second degree polynomial fitting coefficints of the interval, C_1, C_2, and C_3, and the $\log_{10}$ (diameter), D1:

$$\begin{aligned} \mathrm{PPP} &= \log M \qquad (215) \\ &= C_1 + C_2(\mathrm{D1}) + C_3(\mathrm{D1})^2 \end{aligned}$$

and the value of the derivative of PPP with respect to D1, DELMBC, as determined by C_2, C_3, and D1:

$$\begin{aligned} \mathrm{DELMBC} &= d\log M/d\log D \\ &= C_2 + 2C_3(\mathrm{D1}) \qquad (216) \end{aligned}$$

The change in cumulative mass concentration dM/dlogD is also named DELMBC. Thus, DELMBC is redefined:

$$\begin{aligned} \mathrm{DELMBC} &= dM/d\log D \qquad (217) \\ &= 2.302585\ \mathrm{DELMBC}\ (10.0)^{\mathrm{PPP}} \end{aligned}$$

(See the discussion of JOE2 where it is shown that:

$$\frac{dM}{d(\log D)} = 2.302585\ \frac{d(\mathrm{PPP})}{d(\mathrm{D1})}\ (10.0)^{\mathrm{PPP}}\ ). \qquad (218)$$

358-372: dM/dlogD is in units of milligrams per actual cubic meter if NDK = -1. It is in milligrams per dry normal cubic meter, DELM, if NDK = 0. To make the conversion, DELMBC is divided by the factor CONVRT:

$$\mathrm{CONVRT} = (294/\mathrm{TKS})\ \mathrm{POA}\ [(100.0-\mathrm{FGH2O})/100.0] \qquad (219)$$

where TKS = temperature of stack (°K)

POA = gas pressure at the impactor inlet (atmosphere)

FGH2O = percent water content of the gas

dM/dlogD may be converted to dN/dlogD, DELN, if NDK = 1, by dividing by particle density and volume:

$$\text{DELN} = (6.0/\rho\ \pi\ D^3)\ \text{DELM} \times 10^9 \qquad (220)$$

where P = assumed particle density (gm/cm^3)

D = particle diameter (μm)

DELM = dM/dlogD (mg/ACM)

The variable DEL_{IS} is defined as the change in concentration at the given diameter DPLOT in one of three systems of units, depending on the value of NDK as discussed here.

373: The loop which began at card 304 ends here. The loop returns to calculate DEL_{IS} at the same diameter DPLOT and same assumed particle density, ρ, for the next run until DEL_{IS} has been calculated for all like density runs at the same diameter.

374-375: The code variable IAVLD is to be used in the call to subroutine AVCON. By setting IAVLD = 1, AVCON will calculate 50% confidence limits if there are enough data to calculate these, i.e., two or more values.

376-387: If average cumulative mass loading is being calculated NDK = -1.

388-389: The value of code variable $NOCON_{NSLOT}$ signals, upon return from AVCON, whether there were enough data to calculate confidence limits. It is input to AVCON as 0 and remains this value if confidence limits are calculated. It is set equal to 1 if the confidence limits are not calculated. Also, the average change in particle concentration, AVD (units depend on value of NDK), is initialized as 0.0.

390-426: Subroutine AVCON, (N, IAVLD, NDK, $\mathrm{NOCON}_{\mathrm{NSLOT}}$, ISFIN, DEL, AVD, AVDM1, $\mathrm{CUM2D}_{\mathrm{NSLOT}}$, CUM2LD, CISUM, SIGMA, $\mathrm{CLU}_{\mathrm{SNLOT}}$, $\mathrm{CLL}_{\mathrm{NSLOT}}$, DINC) is called to calculate the average, AVD, of all suitable values of DEL. "Suitable values" refers to the exclusion of any negative $\mathrm{DEL}_{\mathrm{IS}}$ value and the exclusion of any $\mathrm{DEL}_{\mathrm{IS}}$ value determined to be an outlier (such $\mathrm{DEL}_{\mathrm{IS}}$ values are set = -50.0 in subroutine AVCON as an arbitrary negative "flag" value). An average of the cumulative mass concentration, CUM2D, is also calculated for each increment in $\log_{10}D$ if NDK = 1. CUM2D represents this average cumulative mass loading less than the specified diameter in milligrams per actual cubic meter. If there is a sufficient number of data values, the upper and lower 50% confidence limits, $\mathrm{CLU}_{\mathrm{NSLOT}}$ and $\mathrm{CLL}_{\mathrm{NSLOT}}$, respectively, are also calculated. The method of calculating these limits depends on the value of NDK.

427: NSETS is a code variable which is a simple function of $\mathrm{NOCON}_{\mathrm{NSLOT}}$:

$$\mathrm{NSETS} = \mathrm{NOCON}_{\mathrm{INSLOT}} + 1 \qquad (221)$$

NSETS = 1 is equivalent to $\mathrm{NOCON}_{\mathrm{NSLOT}} = 0$ and indicates that confidence limits are calculated in subroutine AVCON. NSETS = 2 is equivalent to $\mathrm{NOCON}_{\mathrm{NSLOT}} = 1$ and indicates that there is insufficient data for calculation of 50% confidence limits in subroutine AVCON.

428-455: The output of the line printer is dependent on both NDK and NSETS, *i.e.*, the type of average to be calculated and whether confidence limits could be calculated. The diameter index number NSLOT, the diameter DPLOT, and the average (AVD = average differential concentration for NDK = 0 or 1, or CUM2D = average cumulative mass loading less than indicated diameter for NDK = -1) are printed regardless of the value of NSETS. If NSETS = 1, the value of the standard deviations, SIGMA, and the upper and lower 50% confidence limits CLU_{NSLOT} and CLL_{NSLOT} are printed for NDK = 0 or 1. The upper and lower 50% confidence limits only are printed for NDK = -1. If NSETS = 2, "INSUFFICIENT DATA" is printed in each of these positions.

456-465: A loop occurs here which saves values excluded in calculating averages and confidence limits at this diameter (i.e., any DEL_{IS} value < 0.0). The number of values excluded at a given diameter is $NOUT_{NSLOT}$. The record numbers of any excluded values at the given diameter are also saved in a two-dimensional matrix, $THROUT_{NSLOT,NT}$, where NSLOT is the diameter index and NT is an index for the number thrown out. These values are saved so that excluded records may be printed out with the table of averages and confidence limits for each value of NDK. The number of values to be used in calculating averages and confidence limits is saved as NIN.

466: The output device used next depends upon the value of NDK. If the averages and confidence intervals for cumulative mass loading less than indicated diameter (NDK = -1), or for dN/dlogD (NDK=1) are calculated here, the program checks directly to see if plotting is desired at statement 117 (card 467) or 119 (card 477), respectively. If the averages and confidence intervals for dM/dlogD (NDK=0) are calculated here, the program goes to statement 118 (card 475) to first write values into file MPACFL (for use in program PENTRA) before checking to see if plotting is desired.

467-474: The program comes to statement 117 (card 468) for plotting the cumulative mass loading, CUM2D, less than the indicated diameter, DPLOT, along with upper and lower confidence limits CLU_{NSLOT} and CLL_{NSLOT}, respectively, if $NOCON_{NSLOT} = 0$. The confidence limits will not be calculated or plotted if $NOCON_{NSLOT} = 1$. Recall that twice as many diameters are being examined for the average cumulative mass distribution than are examined for either dM/dlogD or dN/dlogD. It is not desirable to plot all these points on the graph, therefore, a test is made so that only every other point is plotted. Only when IPLOT is negative is a point plotted. IPLOT is calculated as:

$$IPLOT = (-1)^{NSLOT} \qquad (222)$$

Plotting is done by calling subroutine STATPT(NDK1, $NOCON_{NSLOT}$, DPLOT, $CUM2D_{NSLOT}$, CLU_{NSLOT}, CLL_{NSLOT}, XMAX, XMIN, YMAX, YMIN, XS, YS) if IPLOT = -1. Since NDK = 0 when this subroutine is called, the plotting will be done on a log-log grid. The maximum and minimum axis values XMAX, XMIN, YMAX, and YMIN along with scale factors XS and YS are also input to STATPT. These are calculated in subroutine STPLOT. If cumulative mass loading less than indicated diameter is calculated (NDK= -1), the average dM/dlogD at the indicated diameter in milligrams per actual cubic meter, AVD, is redefined as AVDM1, the average dM/dlogD at the previous diameter in the same units. Likewise, the cumulative mass loading less than the indicated diameter in milligrams per actual cubic meter, CUM2D, is redefined as AVDM1, the average dM/dlogD at the previous diameter in the same units. Likewise, the cumulative mass loading less than the indicated diameter in milligrams per actual cubic meter, CUM2D, is redefined in a similar fashion as CUM2LD, the cumulative mass loading less than the previous diameter. The program then goes to statement 150 (card 480) where D1 is incremented by DINC and calculations are repeated for the new diameter.

475-476: The program comes to statement 118 (card 475) if calculation of average dM/dlogD is made (*i.e.*, if NDK = 0). Here, an entry is made into the sequential access file MPACFL (file 16 if making statistical calculations for inlet data, file 17 if for outlet data) for use in the penetration-efficiency program PENTRA. The values written into this record are the diameter in micrometers at which the average dM/dlogD value is being calculated, DPLOT, the average dM/dlogD value in milligrams per normal dry cubic meter, AVD, the standard deviation of this average in the same units, SIGMA, and the number of dM/dlogD values used to find this average and standard deviation, NIN. The program then checks plot coding IPLT2. If a plot of average dM/dlogD vs. diameter, DPLOT, is desired, IPLT2 $\leq$ 0 (usually IPLT2=0), and the program goes to statement 140 (card 478) for plotting. Otherwise, the program goes to statement 150 (card 480) to increment the $\log_{10}$(diameter) and traverse again the loop ending at statement 200 (card 481) for the new diameter variable, D1.

477: Plot coding IPLT3 for plotting average dN/dlogD vs. diameter DPLOT is checked here. If the plot is desired, IPLT $\leq$ (usually IPLT3=0), and the program goes to statement 140 (card 478) for plotting. Otherwise, the program goes to statement 150 (card 480) to increment the $\log_{10}$(diameter) and traverse again the loop ending at statement 200 (card 481) for the new diameter variable, D1.

478-479: The program comes to statement 140 (card 478) for plotting the average dM/dlogD or dN/dlogD value at the indicated diameter, DPLOT, along with upper and lower 50% confidence intervals CLU_{NSLOT} and CLL_{NSLOT}, if $NOCON_{NSLOT} = 0$. Again, there are no confidence limits plotted if $NOCON_{NSLOT} = 1$. The subroutine STATPT is called with the same result as at statement 2117 (cards 470-471) except that an average differential size distribution value, AVD, is plotted instead of an average cumulative mass loading less than indicated diameter, CUM2D.

480-481 The diameter variable $D1 = \log_{10}$(diameter) is incremented here and the program returns to the beginning of this loop (card 289) to make calculations at the new diameter.

482-498: A table of records whose outlying values were excluded from averaging at each diameter is printed out here. The table shows a heading of the general identification label IDALL and assumed density RHOX. Such a table is printed for each value of NDK, i.e., one each for mean cumulative mass concentration less than particle diameter (NDK= -1), mean dM/dlogD (NDK=0), and mean dN/dlogD (NDK -1). Such a table is not printed out for mean cumulative percent concentration less than particle diameter. However, the table would be the same as that for mean cumulative concentration.

499-508: The value of NDK is checked here. If values of average cumulative mass loading less than the indicated diameter have been calculated (NDK= -1), or if values of average dN/dlogD at the indicated diameter have been calculated (NDK=1), the program goes directly to check if a plot has been made (to statement 255 at card 513 or to statement 252 at card 618, respectively) so that the pen can be put back in its "home position" at the base of the plotter paper 2 inches beyond the maximum X -axis. If values of average dM/dlogD at the indicated diameter have been calculated (NDK=0) the program goes to statement 251 (card 606) to make the final entry into the file MPACFL for the density which is a series of 5 asterisks, DAST, in place of diameter, mean dM/dlogD, and standard deviation. Then a check is made to see if the plotter is being used as above.

509-525: The program comes to statement 255 (card 513) for NDK = -1 to check if a plot of cumulative mass loading less than indicated is being made. If so, IPLT1 = 0, and the program goes to statement 304 (card 619) to put the pen in its "home position" after plotting. If not (IPLT1=1), the program goes to statement 253 (card 525) to write the headings for average cumulative percent mass loading less than indicated diameter. As before, this includes the general identification label IDALL and the assumed particle density RHOX. Also, column headings are printed for diameter index number, indicated diameter, average cumulative percent mass loading less than indicated diameter, upper 50% confidence limit, and lower 50% confidence limit.

526-539: If a plot of average cumulative percent mass loading vs. diameter is desired, IPLT4 = 0. In this case, the program goes to statement 257 (card 535) to call subroutine CPPLOT (IDALL, RHOX, XMAX, XMIN, YMAX, YMIN, XS, YS) which draws a log probability vs. common log grid, labels the axes for cumulative percent mass loading vs. particle diameter, and writes the general identification label IDALL and density RHOX above the grid. If the plot is not desired (IPLT4=1), the call to CPPLOT is skipped, and the program goes to statement 258 (card 539) where the first diameter variable for calculating average cumulative percent mass loading, D1, is defined:

$$D1 = \log_{10} (0.25) \qquad (223)$$

540: The code variable NKD1 is set equal to a -1 as an indication to the plotting subroutine STPLOT that these points are to be plotted on a grid with a log probability vertical axis (rather than a common log axis as for previous plotting where NDK1 = 0).

541-456: A loop begins here continuing to statement 270 (card 599) which plots average cumulative percent mass loading less than indicated diameter vs. diameter with 50% confidence limits. The loop also gives a tabular line printer output of these values. The common log of the indicated diameter is incremented on each traverse of the loop.

547-550: The antilog of the plotted diameter variable D1 is taken, yielding the output value for the line printer, DPLOT:

$$DPLOT = 10.0^{D1} \qquad (224)$$

551-560: The cumulative mass loading in milligrams per actual cubic meter less than indicated diameter $CUM2D_{NSLOT}$, along with its upper and lower 50%

confidence limits with the same units CLU_{NSLOT} and CLL_{NSLOT}, respectively, have been calculated. These values are now converted to the cumulative fraction of mass loading less than indicated diameter with fractional upper and lower confidence limits by dividing by the average total mass loading in milligrams per actual cubic meter, $ATGL_N$:

$$CUM2D_{NSLOT} = CUM2D_{NSLOT} /ATGL_N \quad (225)$$

$$CLU_{NSLOT} = CLU_{NSLOT} /ATGL_N \quad (226)$$

$$CLL_{NSLOT} = CLL_{NSLOT} /ATGL_N \quad (227)$$

561: The code variable IPLOT is calculated so that odd values of the diameter index number, NSLOT, yield IPLOT = -1, while even NSLOT values yield IPLOT = 1. Recall that there are twice as many values of cumulative mass loading values as there are values of dM/dlogD or dN/dlogD and, therefore, twice as many cumulative percent mass loading values. To keep the graph from being too crowded with points, only those diameters for which IPLOT = -1 are plotted.

562: If a graph of cumulative percent mass loading less than indicated diameter vs. diameter is not desired (IPLT4=1), or if a particular point is not one which is to be plotted ($IPLOT \neq -1$), the call to subroutine STATPT which would have plotted the point is skipped.

563-569: The program calls subroutine STATPT (NDK1, NOCON $_{NSLOT}$, D1, $CUM2D_{NSLOT}$, CLU_{NSLOT}, CLL_{NSLOT}, XMAX, XMIN, YMAX, YMIN, XS, YS) to plot the cumulative percent mass loading less than indicated diameter $CUM2D_{NSLOT}$ along with its 50% confidence limits, CLU_{NSLOT} and CLL_{NSLOT}, vs. the indicated diameter

DPLOT. Since NDK1 is input to the subroutine as 1, the variables $\mathrm{CUM2D}_{\mathrm{NSLOT}}$, $\mathrm{CLU}_{\mathrm{NSLOT}}$, and $\mathrm{CLL}_{\mathrm{NSLOT}}$ are used to find plotting variables in terms of the log probability scale for the vertical axis. (Recall that for NDK1 = 0, these arguments would be used to find plotting variables in terms of a common log scale). Note that $\mathrm{CUM2D}_{\mathrm{NSLOT}}$, $\mathrm{CLU}_{\mathrm{NSLOT}}$, and $\mathrm{CLL}_{\mathrm{NSLOT}}$ are input as fractions although the log probability scale used for the plot shows these values as percentages. Also, when NDK1 = 1, the indicated diameter D1 is input already in terms of the common log scale. Recall that for NDK1 = 0, this argument is input as the literal diameter DPLOT and must be converted to a common log variable within subroutine STATPT. The upper and lower 50% confidence limits are not plotted if $\mathrm{NOCON}_{\mathrm{NSLOT}}$ is input as 1. This indicates insufficient data for calculation of the confidence limits and $\mathrm{CLU}_{\mathrm{NSLOT}}$ and $\mathrm{CLL}_{\mathrm{NSLOT}}$ in this case are only dummy arguments. For $\mathrm{NOCON}_{\mathrm{NSLOT}} = 0$, the confidence limits are plotted. The maximum and minimum axis limits, XMAX, XMIN, YMAX, AND YMIN, and the scale factors, XS and YS, are input as calculated from CPPLOT.

570-576: $\mathrm{CUM2D}_{\mathrm{NSLOT}}$, $\mathrm{CLU}_{\mathrm{NSLOT}}$, and $\mathrm{CLL}_{\mathrm{NSLOT}}$ were input to subroutine STATPT above as cumulative fraction of mass loading less than indicated diameter and as fractional upper and lower 50% confidence limits. These are converted to percentages for line printer output:

$$\mathrm{CUM2D}_{\mathrm{NSLOT}} = 100\ \mathrm{CUM2D}_{\mathrm{NSLOT}} \qquad (228)$$

$$\mathrm{CLU}_{\mathrm{NSLOT}} = 100\ \mathrm{CLU}_{\mathrm{NSLOT}} \qquad (229)$$

$$\mathrm{CLL}_{\mathrm{NSLOT}} = 100\ \mathrm{CLL}_{\mathrm{NSLOT}} \qquad (230)$$

577-593: There are two line printer output forms which may be used. If the confidence limits are calculated ($\text{NOCON}_{\text{NSLOT}}=0$), the program uses the write statement at card 585 to print values of the diameter index number NSLOT, the diameter in micrometers DPLOT, the cumulative percent mass loading $\text{CUM2D}_{\text{NSLOT}}$, the upper 50% confidence limit $\text{CLU}_{\text{NSLOT}}$, and the lower 50% confidence limit $\text{CLL}_{\text{NSLOT}}$, in their respective columns. If the confidence limits are not calculated ($\text{NOCON}_{\text{NSLOT}}=1$), the program skips to statement 261 (card 593) to write NSLOT, DPLOT, and $\text{CUM2D}_{\text{NSLOT}}$ as above. However, in the columns for $\text{CLU}_{\text{NSLOT}}$ and $\text{CLL}_{\text{NSLOT}}$, "INSUFFICIENT DATA" is written. This indicates that there are less than three values of cumulative percent mass loading less than the indicated diameter within the allowed deviation from the average; (see subroutine AVCON) and therefore insufficient data for calculating confidence limits.

594-599: The diameter variable D1 = $\log_{10}$(diameter) is incremented, and the loop is repeated at card 546 using this new value of the diameter variable.

600-605: If cumulative percent mass loading less than indicated diameter vs. diameter has been plotted (IPLT4=0), the program goes to statement 304 (card 619) where the pen is put back at its "home position." Otherwise, the program goes directly to statement 254 (card 623). This is the end of the loop with MDK as index. The program returns to the top of the loop at card 180 where MDK = 2 and NDK = 0. Calculations are now made for dM/dlogD vs. diameter.

606-612: When all calculations have been completed for dM/dlogD vs. diameter, the program comes to statement 251. Here the last entry, DAST, is made into file MPACFL for this particle density. DAST is defined in a data statement as 5 asterisks. This will be a signal in program PENTRA that all data for this density has been processed to find penetration and efficiency. Program STATIS now checks to see if plotting was done for the dM/dlogD vs. diameter graph. If so, IPLT2 = 0, and the program goes to statement 304 (card 619) to place the pen back in its "home position." Otherwise, the program goes directly to statement 254 (card 623) which is the end of the loop where MDK is the index. The program returns to the top of the loop at card 180 where MDK now = 3 and NDK = 1. Calculations are now made for dN/dlogD vs. diameter.

613-618: When all calculations have been completed for dN/dlogD vs. diameter, the program comes to statement 252 (card 618). Here the program checks to see if plotting was done for dN/dlogD at indicated diameter vs. diameter. If so, IPLT3 = 0, and the program goes to statement 304 (card 619) to place the pen back in its "home position." Otherwise, the program goes to statement 254 (card 623) which is the end of the loop where MDK is the index. The range of MDK is from 1 to 3. On this traverse, MDK = 3, and all calculations of this loop from card 180 to card 574 have been completed for the assumed particle density.

623-624: Recall that the assumed particle density is indicated by the code variable N = 1 for physical and N = 2 for unit density. If all functions have been completed for physical density (i.e., if N=1), the program returns to statement 1 (card 68) to read in the required information for carrying out all of these same functions where the assumed density is aerodynamic density (N=2). If this has already been done, the program stops.

Functions of the Called Subroutines

Subroutine AVCON (N, IAVLD, NDK, NOCON, ISFIN, VAR, AVG, AVGM1, CUM2D, CUM2LD, CISUM, SIGMA, CLU, CLL, DINC)--

Subroutine AVCON flags outliers and then, for remaining values finds the average, AVG, standard deviation, SIGMA, and (if desired) upper and lower 50% confidence limits, CLU and CLL, for a list of input values, VAR.

VAR is an array containing similar values for two different assumed particle densities. Every other value of VAR is used to find the average so that this average represents values based on only one density. The value of N determines the values to be averaged. N = 1 causes odd values (where physical density is assumed) to be averaged. N = 2 causes even values (where unit density is assumed) to be averaged.

The values of VAR are tested for outliers so that any such values may be excluded from the final calculation of the average, standard deviation, and confidence limits. As defined in the Quality Assurance Handbook For Air Pollution Measurement Systems, Vol. 1 Principles (EPA-600/9-76-005, January 1976, Section No. F, pp. 5-9), outliers are defined as a function of the standard deviation (before exclusion):

$$\left[\left(V_I - \bar{V}\right)/s\right] - T_C \geq 0.0 \qquad (231)$$

where V_I = VAR value being tested

$\bar{V}$ = average of the VAR values

s = standard deviation of VAR values = $\left(\dfrac{\sum\limits_{J = N}^{ISFIN,2} \left(V_I - \bar{V}\right)^2}{n - 1}\right)^{\frac{1}{2}}$

N = 1 for evaluation if physical density is assumed

= 2 for evaluation if unit density is assumed

The values of T_c are determined for an upper 5% significance level (i.e. There is only a 5% chance that data outside the range of the critical fraction of σ would be excluded from the statistical analysis in error.) In order to avoid storing the lengthy table of n vs. T_c values in the program, functional forms are fitted to this table with the following results:

$T_c = 1.53,\ n \leq 3$

$T_c = 0.102705 + 2.22946 \log_{10}(n),\ 3 < n < 7$

$T_c = 1.938,\ n = 7$

$T_c = 0.86552 + 1.308037 \log_{10}(n),\ n > 7.$

A second average and standard deviation are calculated excluding the defined outliers. The test is then made a second time, possibly excluding more outliers.

The final average, standard deviation, and confidence limits of the remaining VAR values may now be calculated. The value of IAVLD determines whether 50% confidence limits, CLU and CLL, are desired for the average. If IAVLD = 1, the upper and lower confidence limits are desired and are calculated if there is sufficient data (at least two averaged data values). If there is insufficient data for calculating confidence limits, or if they are otherwise not to be calculated (e.g., for average total mass loading), the subroutine returns to STATIS with NOCON = 1. Assuming that the confidence limits are desired and there is sufficient data, the method of calculation is determined by the NDK value. Recall that NDK = -1 for calculation of average cumulative mass loading, NDK = 0 for calculation of average dM/dlogD, and NDK = 1 for calculation of average dN/dlogD. The method for calculation of confidence limits for the cumulative size distribution involves calculating root mean square values for the increments up to the point of interest.

It might be noted here that the user may wish to use other than 50% confidence limits. If so, change card 128 which defines the confidence interval CONIN. For example, for 90% confidence limits, this card would be changed as follows:

$$\mathrm{CONIN} = \left[\mathrm{SIGMA}\left(1.645 + 2.6048\,(\mathrm{NUPTS} - 1)^{-1.18553}\right)\right] / (\mathrm{NUPTS})^{\frac{1}{2}} \qquad (232)$$

A detailed description of the programming is given here:

015-017: The sum of all tested VAR values, SUM, the number of values in this sum, NUPTS, and the standard deviation of the VAR values, SIGMA, are initialized as 0 here.

018-022: A running sum of the VAR values, SUM, is incremented on each traverse of the loop here along with the number of points in the sum NUPTS. Any VAR value having a negative value is a 'bad data point' and is skipped in this loop.

023-025: If there are three or more 'good values' (i.e., nonnegative, the program finds the average of these, AVG, and continues to make the test for outliers. The value of code variable LL, which indicates the number of times the input values VAR have been tested for outliers, is set equal to 1 for the first test. If there are less than three values, none would be thrown out. In this case the program skips the outlier test and goes to statement 190 (card 083).

026-036: A loop here calculates the sum of the squares of the difference of the odd or even (depending on the value of N) VAR values from the average AVG, to obtain SIGPA. It is not yet standard deviation. NUPTS, initialized as 0, is incremented by one for each value in this sum. Only positive VAR values are included in this sum, which serves to exclude any undesirable values as input from mainline STATIS. Also, for the second calculation of SIGPA, outlier values, which have been set = -50.0, are excluded.

037-042: The standard deviation, SIGMA, of the input VAR values is found here:

$$\text{SIGMA} = (\text{SIGPA} / \text{NUPTS-1})^{\frac{1}{2}} \qquad (233)$$

where SIGPA and NIPTS are as defined above.

043-057: The critical multiplier of SIGMA, TCRIT, which determines the boundaries for the outlier test is found here. The function defining TCRIT is dependent on the number of values being tested (see introductory discussion of subroutine AVCON).

$\text{TCRIT} = 1.153$, for $\text{NUPTS} \leq 3$

$\text{TCRIT} = 0.102705 + 2.22946 \log_{10}(\text{NUPTS})$, for $3 < \text{NUPTS} < 7$

$\text{TCRIT} = 1.938$, for $\text{NUPTS} = 7$

or $\text{TCRIT} = 0.86552 + 1.308037 \log_{10}(\text{NUPTS})$, for $\text{NUPTS} > 7$

058-072: Each value VAR_I is some multiple T of the standard deviation SIGMA away from the average of the VAR values, AVG:

$$T = \left|(\text{VAR}_I - \text{AVG})/\text{SIGMA}\right|$$

A loop here finds this T value for each VAR_I and tests it to see if VAR_I is an outlier, *i.e.*, if $T \geq \text{TCRIT}$. If $T \geq \text{TCRIT}$, VAR_I is "tagged" as an outlier by setting it equal to -50.0. This loop also keeps a running sum of all good VAR_I values and the number of values in the sum NUPTS. Using these, the program can find a second standard deviation, SIGMA, and repeat the test for outliers using the new AVG and SIGMA.

073-081: If this is the first execution of the outlier test (LL=1), and if there are at least three good values remaining on which to test ($\text{NUPTS} \geq 3$), the second average, AVG, is calculated, LL is set equal to LL + 1 = 2, and the program returns to statement 120 (card 025) where SIGPA and NUPTS are reinitialized to 0.0 and 0, respectively. A second standard deviation, SIGMA, is calculated and a second test for outliers is made.

082-094: The program comes to statement 190 (card 083) after all testing for outliers has been conducted. All outlier VAR_I values have a negative value. After initializing SUM, NUPTS, and AVG as 0.0, a running sum, SUM, of the "good" VAR values is kept along with the number of values in this sum, NUPTS.

095-117: The average of these remaining VAR_I's is calculated:

$$AVG = SUM/NUPTS \qquad (234)$$

The standard deviation SIGMA is initialized as 0.0. If the 50% confidence limits are desired (IAVLD=1), and if there are at least two good values from which to calculate the confidence limits ($NUPTS \geq 2$), the program proceeds to statement 1195 (card 121) to calculate SIGMA and the confidence limits CLL and CLU. If IAVLD = 0, subroutine AVCON calculates the average of total mass loading values. In this case, SIGMA, CLL, and CLU are not calculated, NOCON is set equal to 1, and the program returns to the mainline STATIS. Also, if there is only one value of VAR_I, then SIGMA, CLU, and CLL cannot be calculated, and, therefore, NOCON is again set equal to 1. The program returns with only the average dM/dlogD, AVG, and, for NDK = -1, the average cumulative mass concentration less than the indicated diameter CUM2D:

$$CUM2D = CUM2LD + [(AVG)\ (AVGM1]^{1/2}(DINC) \qquad (235)$$

where CUM2LD = average cumulative mass concentration less than the previous indicated diameter

AVG = average value of dM/dlogD at the indicated diameter

AVGM1 = average value of dM/dlogD at the previous diameter, and

DINC = log difference of this and the previous diameter

118-126: This loop iteratively calculates the sum of the squares of the deviation of good VAR values from the average to obtain a precursory value of SIGMA. The final standard deviation SIGMA is then:

$$\text{SIGMA} = \left[\text{SIGMA}/(\text{NUPTS}-1)\right]^{\frac{1}{2}} \qquad (236)$$

127-128: The 50% confidence interval for change in size concentration CONIN is calculated here as a function of the standard deviation, SIGMA, and the number of values averaged, NUPTS. For $\text{NUPTS} \geq 2$:

$$\text{CONIN} = \text{SIGMA}\ (0.674 + 0.32\ (\text{NUPTS} - 1)^{-1.072})\ /(\text{NUPTS})^{\frac{1}{2}}$$

CONIN is the 50% confidence interval for dM/dlogD, in milligrams per actual cubic meter if NDK = -1, dM/dlogD in milligrams per dry normal cubic meter if NDK = 0, or dN/dlogD in number of particles per dry normal cubic meter if NDK = 1. (See the introduction to this description of AVCON for 90% confidence limits.)

129-160: The method of finding upper and lower 50% confidence intervals, CLU and CLL, respectively, is dependent on the type of calculations being made. If finding the average and confidence limits for cumulative mass loading (NDK = -1), the program comes to statement 150 (card 149), and a running sum of the average dM/dlogD's up to the previous diameter, CUM2LD, is brought into the subroutine. CUM2LD represents the area under the curve for average dM/dlogD vs. diameter (on log-log scale) up to the previous diameter. Also, the value of the average dM/dlogD at the previous diameter, AVGM1, is one of AVCON's arguments. In order to calculate the average cumulative mass concentration up to this diameter, CUM2D, another increment must be added:

$$\text{CUM2D} = \text{CUM2LD} + [(\text{AVG})(\text{AVGM1})]^{\frac{1}{2}}(\text{DINC}) \quad (237)$$

where CUM2LD = sum of average dM/dlogD, or cumulative mass concentration less than the previous diameter

AVG = average dM/dlogD at this diameter

AVGM1 = average dM/dlogD at the previous diameter, and

DINC = difference in the common logarithms of this diameter and the previous diameter.

The upper and lower confidence limits for the average cumulative mass concentration, CLU and CLL, respectively, are found by using the root mean square of the confidence intervals for average dM/dlogD up to the indicated diameter, $(\text{CISUM})^{\frac{1}{2}}$. This value multiplied by the differential logarithms of this and the previous diameter, yields the confidence interval for average mass size concentration at the indicated diameter. Thus, the average mass size concentration confidence limits are expressed as:

$$\text{CLU} = \text{CUM2D} + (\text{CISUM})^{\frac{1}{2}}(\text{DINC}), \text{ and}$$
$$\text{CLL} = \text{CUM2D} - (\text{CISUM})^{\frac{1}{2}}(\text{DINC})$$

For finding these 50% confidence limits for average dM/dlogD (where NDK = 0) or for average dN/dlogD (where NDK = -1), the confidence interval calculated at card 128, CONIN, is added to or subtracted from the average:

CLU = AVG + CONIN, and
CLL = AVG - CONIN

The program now returns to mainline program STATIS.

Subroutine STPLOT (IDALL, RHO, IMPAC, NDK, PDMIN, DXMAX, DXMIN, ISIZ, XS, YS, XMAX, XMIN, YMAX, YMIN)--

Subroutine STPLOT draws a common log vs. common log plotting grid, labels the axes appropriately for the type of plotting to be done according to NDK, and writes the general identification label IDALL and the assumed particle density RHO above the grid. If NDK = -1, the grid is for average cumulative mass loading less than indicated diameter in milligrams per actual cubic meter vs. diameter in micrometers. If NDK = 0, the grid is for average value of dM/dlogD in milligrams per dry normal cubic meter vs. diameter in micrometers. If NDK = 1, the grid is for average dN/dlogD in number of particles per dry normal cubic meter vs. diameter in micrometers. The range and number of plotting cycles is dependent on ISIZ. If ISIZ = 0, there is a standard range and number of cycles depending on the type of plotting to be done (as determined by NDK as above) and on the impactor used which is determined by the code value IMPAC. If ISIZ = 1, the range and number of cycles are regulated according to the data. For data regulated plotting limits, 100 micrometers and DXMIN are the maximum and minimum horizontal axis limits, respectively, and PDMAX and PDMIN are the maximum and minimum vertical axis limits, respectively.

The scale factors XS and YS which are in inches per user's unit for each axis and the common log of the axes limits XMAX, XMIN, YMAX, and YMIN are calculated for use in the subroutine STPLOT. These variable values are returned as arguments to mainline STATIS for use in plotting the individual points in subroutine STATPT.

Subroutine STPLOT incorporates several subroutines adapted for use with the DEC PDP-15/76 computer system. These subroutines are defined in the Appendix. Users of the subroutine STPLOT will probably have to reprogram this subroutine for use with their particular computing system.

A detailed description of the programming is given here:

022: Define PI = 3.1415.

023: The output device to be used for writing in this subroutine has the code name M and is defined here as 7 which is the device number for the plotter.

024-025: The value of N is determined by the assumed particle density RHO. If the grid is to be drawn to plot data where physical density is assumed, N = 1. If the grid is to be drawn to plot data where unit density (RHO = 1.0 gram per cubic centimeter) is used, N = 2.

026-031: The length of the horizontal and vertical axes, XIN and YIN, respectively, are defined in inches:

XIN = 4.5, and
YIN = 6.5

032-050: If ISIZ = 1, the maximum and minimum limits of the graph are regulated according to the data. This is done beginning at statement 25 (card 073). Otherwise, ISIZ = 0, and the program continues to define the maximum and minimum limits according to the type of plotting done and the impactor used to obtain the data.

051-067: If the grid being drawn is for average cumulative mass loading vs. diameter (NDK = -1), the maximum and minimum vertical axis limits, YMAX and YMIN, respectively, are as follows:

$YMAX = 10^4$, and
$YMIN = 10^{-1}$

If the grid is for either average dM/dlogD (NDK = 0) or dN/dlogD (NDK = 1), these limits are also determined by the impactor used. For NDK = 0, if the Andersen Mark III (IMPAC = 1) University of Washington (IMPAC = 3), or Meteorology Research, Inc., (IMPAC = 4) cascade impactors, these limits are:

$YMAX = 10^4$, and
$YMIN = 10^{-2}$

For NDK = 0, if the Brink cascade impactor is used, these limits are:

$YMAX = 10^6$, and
$YMIN = 10^0$

For NDK = 1, if the Andersen Mark III (IMPAC = 1), University of Washington (IMPAC = 3), or Meteorology Research, Inc., (IMPAC = 4) cascade impactor is used, these limits are:

$YMAX = 10^{15}$, and
$YMIN = 10^6$

If NDK = 1, and the Brink cascade impactor is used,

$YMAX = 10^{14}$, and
$YMIN = 10^5$

068-072: The limits actually used by the plotter are the common logarithms of the standard values and are defined as such here. The horizontal maximum and minimum axis limits, XMAX and XMIN, are also defined here as common logs. XMAX and XMIN are the same values regardless of the type of grid being drawn or the impactor used. The final form of the axes limits are:

$$XMAX = \log_{10}(100.0) = 1$$
$$YMAX = \log_{10}(YMAX)$$
$$XMIN = \log_{10}(0.1) = -1, \text{ and}$$
$$YMIN = \log_{10}(YMIN)$$

073-076: If the axes limits are to be regulated according to the data rather than defined as standard values, *i.e.*, if ISIZ = 1, the program uses the function SLIM (MAXMIN, ALIMIT) to find these common log limits. If MAXMIN = 1, SLIM returns a maximum axis limit which is a function of ALIMIT. If MAXMIN = 0, SLIM returns a minimum axis limit which is a function of ALIMIT. The limits, therefore, for ISIZ = 1 are:

$$XMAX = SLIM\ (1, \log_{10}(100.0))$$
$$= SLIM\ (1, 1.0) = 1.0$$
$$YMAX = SLIM\ (1, \log_{10}(DXMAX_N))$$
$$XMIN = SLIM\ (0, \log_{10}(PDMIN_N)) \text{ and}$$
$$YMIN = SLIM\ (0, \log_{10}(DXMIN_N))$$

$DXMAX_N$ is the average total mass loading of all runs where the same particle density is assumed if NDK = -1 or NDK = 0, or is the average maximum value of all the number size distributions of the same assumed density if NDK = 1. $PDMIN_N$ is the average minimum D_{50} for all runs of the same assumed particle density if NDK = -1, and is the average minimum geometric mean diameter if NDK = 0 or NDK = 1. $DXMIN_N$ is the average cumulative mass loading at the last impactor stage for all runs of the same assumed density if NDK = 1 or 0, or is the average minimum value of all the number size distributions of the same assumed particle density if NDK = 1. The value of XMAX is a standard value = 2.0 even though ISIZ = 1.

077-081: The horizontal and vertical axis scale factors, XS and YS, are calculated here in inches per user's unit (inches per common log scale). XS is a function of the length of the horizontal axis in inches XIN, the maximum limit of the axis XMAX, and the minimum limit of the axis XMIN:

$$XS = XIN/(XMAX-XMIN) \qquad (238)$$

Likewise YS is a function of the length of the vertical axis in inches YIN, the maximum limit of the axis YMAX, and the minimum limit of the axis YMIN:

$$YS = YIN/(YMAX-YMIN) \qquad (239)$$

082: Define the Y-coordinate of the pen, YO, in its original position, i.e., when subroutine STPLOT is called, in terms of the Y-coordinate of the user's origin, YMIN, and the Y-axis scale factor, YS. The pen should be on the lower baseline of the plotting paper when any plotting subroutine is called. The user's origin should be placed 2 inches above this point in order to make room below for the labeling of the horizontal X-axis. (Also, this allows room for figure captions if the plot is to be placed on 8-1/2 x 11" paper.) Thus, YO is defined as:

$$YO = YMIN - (2./YS) \qquad (240)$$

083: The call to plotter subroutine SCALF (XS, YS, XMIN, YO) stores X- and Y-axis scale factors XS and YS, in inches per user's unit, and the original location of the pen (XMIN, Y) in user's units for later reference by the plotter.

084-088: Calculate the number of X-axis cycles IXRAN by calculating the difference of the X-axis limits XMAX and XMIN:

$$IXRAN = XMAX-XMIN$$

089: The call to plotter subroutine XSLBL (XS, YS, XMIN, YMIN, IXRAN, XMIN) labels the X-axis for $\log_{10}$ scale.

090: The call to plotter subroutine XLOG (XS, YS, XMAX, YMIN, -1, IXRAN) draws the X-axis for $\log_{10}$ scale.

091-096: Define the desired width and height of written characters in inches, XCS and YCS, respectively, for labeling the X-axis:

$$XCS = 0.15$$
$$YCS = 0.15$$

097-098: Define the point (X,Y) in user's units at which the labeling of the X-axis is to begin. This position should be at the lower left-hand corner of the position at which the first character is to be drawn. In order to center the label below the X-axis, first define the X-coordinate of the beginning pen position by placing the pen at the center of the X-axis length, *i.e.*, XMIN + (XMAX-XMIN)/2.0. Multiply one-half the total number of characters to be written (including spaces) by the number of inches for each character, XCS. The label to be written is "PARTICLE DIAMETER (MICROMETERS)" which contains 32 characters. Therefore, the number of inches to be "backspaced" from the center is 16 XCS. Dividing XCS by the inches per user's unit along the X-axis XS, one obtains the number of *user's units* to be backspaced for the center point.

Therefore:

$$X=MIN + [(XMAX-XMIN)/2] - (16XCS/XS) \qquad (241)$$

The Y-coordinate is defined low enough below the X-axis so that there is space to draw the height of the characters (0.15 inch) without interfering with the drawn X-axis. The Y-coordinate is therefore defined as 0.7 inch below the X-axis allowing 0.55 inch between the top of the characters and the Y-axis:

$$Y = YMIN - 0.7/YS$$

099: Call the plotter subroutine FCHAR(X, Y, XCS, YCS, 0.0) to initialize the annotation subroutine by establishing the starting location for the pen (X, Y) in user's units, the width and height of the characters in inches, XCS and YCS, respectively, and the angle of writing in radians relative to the X-axis, here 0.0.

100-103: Write the X-axis label "PARTICLE DIAMETER (MICROMETERS)".

104-108: Redefine the width and height of written characters in inches, XCS and YCS, respectively, for writing the general identification label IDALL above the grid:

$$XCS = 0.056, \text{ and}$$
$$YCS = 0.100$$

109-110: Define the point (X,Y) at which writing will begin for the general identification label IDALL as being in line with the Y-axis at X = XMIN and one-half inch above the grid at Y = YMAX + (0.5/YS).

111-119: A DO-loop searches for the last character of the identification label IDALL(J) to prevent any unnecessary movement of the pen for an identification label of less than 80 characters.

120: The call to plotter subroutine FCHAR (X, Y, XCS, YCS, 0.0) initializes the annotation subroutine by establishing the starting location for the pen (X,Y) in user's units, the width and height of the characters in inches, SCS and YCS, respectively, and the angle of writing in radians, 0.0.

121-124: Write the general identification label IDALL_I.

125-126: Redefine the beginning pen location (X,Y) in user's units for writing the particle density RHO. The beginning X-coordinate is located so that the first character is in line with the Y-axis. The beginning Y-coordinate is 0.25 inch above the maximum Y-axis value so that with characters 0.12 inch in height, there is approximately a 0.12 inch margin between the writing of RHO and IDALL:

$$X = XMIN, \text{ and}$$
$$Y = YMAX + (0.25/YS)$$

127: Call the plotter subroutine FCHAR (X, Y, XCS, YCS, 0.0) to initialize the annotation subroutine by establishing the starting location for the pen (X,Y) in user's units, the width and height of the characters in inches, XCS and YCS, respectively, and the angle of writing in radians with respect to the X-axis, 0.0.

128-131: Write the assumed particle density "RHO =

132-137: Calculate the number of Y-axis cycles IYRAN by taking the difference of the Y-axis limits IYMAX and IYMIN:

$$IYRAN = IYMAX - IYMIN \qquad (242)$$

138: The call to plotter subroutine YLOG (XS, YS, XMIN, YMAX, -1, IYRAN) draws the Y-axis on the left of the graph for common log scale.

139: The call to plotter subroutine LGLBL (XS, YS, XMIN, YMIN, IYRAN, YMIN, 1) labels the Y-axis on the left of the axis for common log scale.

140-144: Redefine the width and height of written characters, XCS and YCS, respectively, in inches for labeling the Y-axis:

$$\mathrm{XCS} = 0.15, \text{ and}$$
$$\mathrm{YCS} = 0.15$$

145-146: The pen position in user's units (X, Y) is defined for the beginning of the X-axis label. The Y coordinate is such that the writing is centered along the length of the Y-axis. The X-coordinate is such that the base of the characters does not interfere with the drawn Y-axis. See the discussion of cards 097-098 for a detailed example of how these coordinates are calculated:

$$X = \mathrm{XMIN} - (0.7/\mathrm{XS}), \text{ and} \tag{243}$$
$$Y = \mathrm{YMIN} + [(\mathrm{YMAX}-\mathrm{YMIN})/2] - [(17)(\mathrm{XCS})/\mathrm{YS}] \tag{244}$$

147: The call to plotter subroutine FCHAR (X, Y, XCS, YCS, PI/2.) initializes the annotation subroutine by establishing the starting location of the pen (X, Y) in user's units, the width and height of the characters in inches, XCS and YCS, and the angle of writing in radians with respect to the X-axis, $\pi/2$.

148-157: The labeling of the Y-axis depends on the type of graphing being done, i.e., on the value of NDK. If NDK = -1, cumulative mass loading less than indicated diameter vs. diameter is being plotted, and the program goes to statement 41 (card 158). The section not only labels this left Y-axis appropriately, but also draws a Y-axis on the right for English units, and labels it appropriately. If NDK = 0, average dM/dlogD vs. diameter is being plotted, and the program goes to statement 42 (card 174) for labeling. If NDK = 1, average dN/dlogD vs. diameter is being plotted, the program goes to statement 43 (card 176) for labeling.

158: The write statement here labels this left Y-axis as "CUMULATIVE MASS LOADING (MG/ACM)".

159-163: The program continues here for NDK = -1 to draw a Y-axis on the right side of the graph for cumulative mass loading less than indicated diameter in grains per actual cubic foot. One milligram per actual cubic meter converts to 4.37×10^{-4} grains per actual cubic foot. In terms of common logs, a value of 0 on the milligrams per actual cubic meter scale is parallel to a value of -3.3595 on the scale of grams per actual cubic foot; a value of 1 on the former scale is equivalent to -2.3595 on the latter scale, etc. If one wishes to begin the Y-axis on the right (in English units) at an integral value, a fraction of a scale equal to 0.3595 must be added to the left Y-axis origin position YMIN. Thus, the vertical pen position for the beginning of the right Y-axis in terms of the left Y-axis metric units is:

$$YO = YMIN + 0.3595$$

This begins the left Y-axis at a position which has an integral value in English units. To arrive at this integral value YLEF, one must subtract the remainder of the common log conversion factor (which is 3) from the left Y-axis origin YMIN:

$$YLEF = YMIN -3$$

164: The call to plotter subroutine LGLBL (XS, YS, XMAX, YO, IYRAN, YLEF, O) labels this right-hand Y-axis on the right of the axis for common log scale.

165: The call to plotter subroutine YLOG (XS, YS, XMAX, YMAX +0.3595, -1, IYRAN) draws the Y-axis on the right side of the graph for common log scale.

166-170: The pen position in user's units (X, Y) is defined for the beginning of the right Y-axis label. The Y-coordinate is such that the writing is centered along the length of the left Y-axis. The coordinate is such the height of the characters does not interfere with the right Y-axis. See the discussion of cards 097-098 for a detailed example of how these coordinates are calculated:

$$X = XMAX + (0.8/XS), \text{ and} \qquad (245$$

$$Y = YMIN + [(YMAX + 0.3595) - YMIN]/2.0 - [(16XCS/YS)] \qquad (246$$

171: The call to plotter subroutine FCHAR (X, Y, XCS, YCS, PI/2.) initializes the annotation subroutine by establishing the starting location of the pen (X, Y) in user's units, the width and height of the characters in inches, XCS and YCS, respectively, and the angle of writing in radians with respect to the X-axis, $\pi/2$.

172-173 Write "CUMULATIVE MASS LOADING (GR/ACF)" along the right side of the right Y-axis. Go to statement 60 (card 177) where the program returns to mainline STATIS.

174-175: The program comes to this write statement when NDK = 0 and appropriately writes "DM/DLOGD (MG/DNM3)" along the Y-axis. Go to statement 60 (card 177) where the program returns to mainline STATIS.

176-177: The program comes to this write statement when NDK = 1 and appropriately writes "DN/DLOGD (NO.

PARTICLES/DNM3)" along the Y-axis. The program then returns to mainline STATIS.

Subroutine STATPT (NDK1, NOCON, DPLOT, BVD, DLU, DLL, XMAX, XMIN, YMAX, YMIN, XS, YS)--

Subroutine STATPT is called from the mainline program STATIS to plot a point BVD and its upper and lower confidence limits, DLU and DLL, respectively, along a vertical common log scale if NDK1 = 0 (for plotting of cumulative or differential size distribution) or along a vertical probability scale if NDK1 = 1 (for plotting of cumulative percent mass loading). The diameter is plotted along the horizontal common log scale. The average value only is plotted if NOCON = 1. In this case, there is insufficient data for calculation of confidence limits, and DLL and DLU are only dummy arguments. In order to properly locate a point, the horizontal limits, XMAX and XMIN, the vertical limits, YMAX and YMIN, and the number of inches per user's unit along each scale, XS and YS, are also brought into the subroutine as calling arguments from the mainline program STATIS. A detailed description of the programming is given here:

013-016: The average, upper confidence limit, and lower confidence limit are brought into subroutine STATPT as the arguments BVD, DLU, and DLL, respectively. Their names are changed in these first steps to AVD, CLU, and CLL in order that they will be returned as the original values to the mainline program STATIS.

017-025: If NDK1 = 1, this subroutine is plotting percent cumulative mass loading less than particle diameter vs. diameter.

026: If there was insufficient data for the calculation of confidence limits, the argument NOCON comes into STATPT as 1. In this case, the program skips to statement 108 (card 039) omitting the section which converts confidence limits to their common log values.

029-043: The average, AVD, upper and lower confidence limits, CLU and CLL, respectively, and diameter, DPLOT, are converted to common log values for plotting (except for plotting percent cumulative mass loading as noted above). AVD, CLU, and CLL must each be checked for a zero or negative value before taking the common log. If this occurs, the variable is given a "flag value" of -50.0.

044-049: The horizontal pen position for the lower confidence limit is found here as XN. The function XVAL gives the plotted variable, here DPLOT, a value just oustide the plot grid if it exceeds the plotting limits. Otherwise, the value is unchanged.

050-054: If confidence limits could not be calculated, NOCON = 1. Then CLU and CLL (or DLU and DLL) are only dummy variables and the subroutine omits plotting the confidence limit bars. It skips to statement 408 (card 087) to plot only the average value.

055-059: This begins the section for drawing the lower confidence limit bar. If cumulative mass loading, dM/dlogD, or dN/dlogD is being plotted (*i.e.*, NDK1 = 0), the lower confidence limit is already in the common log form to be plotted. The subroutine then goes directly to check this value to see if it is within the plotting grid. This is statement 405 (card 074). Otherwise, NDK1 = 1, and percent cumulative mass concentration is being plotted. The program continues to find the lower confidence limit value in terms of the probability scale.

060-073: The lower confidence limit value CLL is tested to see that it is within the range of 0.001 to 0.9999. If it is above this range, the probability variable YV which represents the lower confidence limit is given the value 4.0. This could be any arbitrary value greater than the normal probability conversion of 0.9999 which is 3.71912. If CLL is below this range, YV is given the value -4.0. This could be any arbitrary value less than the normal probability conversion of 0.0001 which is -3.71912. If CLL is within the 0.0001 to 0.9999 range, its normal probability conversion value YV is determined by the subroutine NDTRI (CLL, YV, D, IE).

074-075: The lower confidence limit value YV (which may be in terms of a probability scale or common log scale as discussed above) is checked by the function YVAL (YV, YMAX, YMIN, YS). If YV is within the plotting limits YMAX and YMIN, its value is not changed. If it does exceed one of these limits, YV is given a value 0.25 inch outside the exceeded limit (*i.e.*, YMAX + 0.25/YS or YMIN - 0.25/YS where YS is the scale factor in inches per user's unit).

076-080: The lower confidence limit bar is drawn here. The beginning horizontal position is 0.03 inch less than the common log of the plotted diameter. The pen draws 0.06 inch across and then back to the original position. The plotter subroutine which moves the pen to each new position (XN, YN) is FPLOT (I, XN, YN). The value of I determines the sequence of raising, lowering, and relocation of the pen.

081-097: This section finds the average in terms of the normal probability scale if NDK1 = 1 (for percent cumulative mass concentration), just as for the lower 50% confidence limit CLL at cards 060-073. Recall that if confidence limits are not to be drawn, the subroutine comes directly to statement 408 (card 087) to draw the average value point without drawing a lower confidence limit bar.

098-099: The pen draws the bar at the common log diameter value from the lower 50% confidence limit to the average by calling the pen control subroutine FPLOT (I, XN, YN). At that point the subroutine SYMBOL (J, R) is called to draw a solid circle (obtained when J = 9) of 0.04 inch in diameter (R = 0.04).

100: If confidence limits are not calculated, NOCON = 1, and the following section for drawing the upper confidence limit bar is omitted. The subroutine goes directly to statement 417 (card 123) where the pen is raised and the program returns to the mainline program STATIS.

101-116: This section finds the lower confidence limit in terms of the normal probability scale if NDK1 = 1 (for percent cumulative mass concentration) just as for the lower 50% confidence limit CLL at cards 060-073 and for the average AVD at cards 081-097.

117-120: The pen draws the bar at the common log diameter value from the average to the upper 50% confidence limit by a call to the pen control subroutine FPLOT (I, XN, YN). There it also draws a small 0.06-inch horizontal upper limit bar by calls to the pen control subroutine FPLOT (I, XN, YN).

121-125: The pen is raised here in preparation for the next call to subroutine STATPT (which will plot the average and upper and lower confidence limits at the next diameter examined). If all points have been drawn, STATPT is not called again, but the pen is in position to be moved to the base of the plotter paper upon return to mainline program STATIS.

Input for Mainline Program

Card Input--

Card A. This card has a code value which indicates whether the data to be analyzed by this execution of program STATIS are inlet data or outlet data.

Column 1: Punch a "1" in column 1 if this execution of STATIS is for analysis of inlet data. Punch a "2" in column 1 if it is for analysis of outlet data.

Card B. This card has a code value which indicates the assumed particle density; a code value which indicates whether statistical calculations are desired for this assumed density; code values to indicate if average cumulative mass loading, average dM/dlogD, average dN/dlogD, and average cumulative percent mass loading, respectively, are to be plotted; and code values for each of these to indicate whether the range and number of plotting cycles is to be standard or to be regulated according to the data.

Column 1: Punch a "1" here in order to make calculations for data where the assumed density is physical density.

Column 2: Punch a "1" here if statistical calculations and plots are not desired for data where physical density is assumed. Punch a "0" here to make these calculations and plots.

Column 3: Punch a "0" here if the plot of average cumulative mass loading less than indicated particle diameter vs. particle diameter for assumed physical density is desired. Punch a "1" here to suppress the plot.

Column 4: Punch a "0" here if the plot of average dM/dlogD vs. particle diameter for assumed physical density is desired. Punch a "1" here to suppress the plot.

Column 5: Punch a "0" here if the plot of average dN/dlogD vs. particle diameter for assumed physical density is desired. Punch a "1" here to suppress the plot.

Column 6: Punch a "0" here if the plot of average cumulative percent mass loading less than indicated particle diameter vs. particle diameter for assumed physical density is desired. Punch a "1" here to suppress the plot.

Column 7: Punch a "0" here for standard range and number of cycles for both axes of the plot of average cumulative mass loading less than indicated diameter vs. particle diameter where physical density is assumed and for the horizontal (diameter) axis of cumulative percent mass loading less than indicated diameter vs. particle diameter where physical density is assumed. Punch a "1" here to regulate the range and number of cycles according to the data.

Column 8: Punch a "0" here for standard range and number of cycles for both axes of the plot of average dM/dlogD vs. particle diameter for assumed physical density. Punch a "1" here to regulate the range and number of cycles according to the data.

Column 9: Punch a "0" here for standard range and number of cycles for both axes of the plot of average dN/dlogD vs. particle diameter for assumed physical density. Punch a "1" here to regulate the range and number of cycles according to the data.

Column 10: Punch a "1" here to calculate a constant of integration for average cumulative mass loading < 0.25 micrometers. Punch a "0" here if the constant of integration is not desired.

Card C. This card contains the maximum particle diameter to be averaged and plotted in micrometers for physical density plots if 8.0 micrometers is not satisfactory. The decimal point must be included since an F5.1 format is used. This card is omitted if column 2 of card B is punched as "1".

Columns 1-5: Punch the maximum desired particle diameter in micrometers for all plots where physical density is assumed if other than 8.0 micrometers. If 8.0 is satisfactory, this card may be left blank. This number cannot be greater than the maximum particle size collected, DMAX. Note: This card is completely omitted if column 2 of card B is punched as "1"

Cards D and E. Repeat as in cards B and C, respectively, with all values punched pertaining to data where unit density (aerodynamic diameters) is assumed. Column 1 of card D must be punched as "2" to indicate that unit density is assumed for all values to follow. As for card C, card E is to be omitted if there is a "1" punched in column 2 of card D. If card E is left blank, this will cause the maximum particle diameter for unit density plots to be 10.0 micrometers rather than 8.0 micrometers, as is the case for physical density plots.

File Input--

The random access file number 10 which has the name "KMC 001" is used for input into program STATIS. It is necessary that first the impactor program MPPROG be executed in order to record information on this file which is needed in STATIS. This includes the number of impactor runs for which there is recorded data, NRUN, the code for type of impactor used, IMPAC, general identification label, IDALL, physical density, RHO1, and the maximum and minimum data limits for geometric mean diameter (GEMAX, GEMIN), dM/dlogD (DMMAX, DMMIN), dN/dlogD (DNMAX, DNMIN), and cumulative mass distribution (CUMAX, CUMIN), the maximum collected particle size, DPMAX, and the minimum stage diameter cut point, DPMIN. Some information pertaining to each individual run is also used from this file. These values are the record number, IS, total mass loading, TGL, stack temperature, TKS, pressure at the impactor inlet, POA, and percent water-vapor content of the gas, FGH20.

The random access file number 11 which has the name "FILSPL" is also used for input into program STATIS. The program which fits curves to the cumulative mass loading less than stage D_{50} vs. D_{50}, called SPLIN1 must be executed before STATIS (and following execution of MPPROG) in order to have the necessary data on file. For each run, these data are the total number of interval boundary points over the $\log_{10}$ (cumulative mass loading) vs. $\log_{10}$ (D_{50}) range, NPOIN, the values of these points XI_I, I = 1, NPOIN and YI_I, NPOIN, and the coefficient values which fit a second degree polynomial over each of these intervals, COE_{IJ}, I = 1, INT, J = 1, 3 (INT = number of fitted intervals = NPOIN -1).

Output for Mainline Program STATIS

Line Printer Output--

Pages 1-2: The general identification label is printed on the first line followed on the second line by the assumed physical density. Written next are column headings for diameter index number, diameter in micrometers, average cumulative mass loading less than this indicated diameter in milligrams per actual cubic meter, upper 50% confidence limit of this average in the same units, and lower 50% confidence limit of this average in the same units. This is followed by a listing of these values for diameters ranging from 0.25

micrometer to 8.0 micrometers (unless otherwise indicated on card C). The increment between diameters here is such that there are 28 diameters over each common log cycle. The line-printer output on pages 1 and 2 is not made if "1" is punched in column 2 of card B.

Pages 3-4: After the general identification label IDALL and assumed physical density RHOX are written, column headings for interval index number, diameter in micrometers, and records excluded from mean cumulative mass concentration are written. A table is then given showing at each diameter from 0.25 micrometer to 8.0 micrometers (unless otherwise specified on card C), the record numbers of any runs for which an outlier value of cumulative mass concentration was calculated. Since the records used in averaging here contain data for assumed physical density, any record numbers shown are odd. For example, if record numbers 5, 11, and 21 are listed at a diameter of 3.27 micrometers, this indicates that the cumulative mass concentration values calculated at 3.27 micrometers where physical density is assumed for runs 3, 6, and 11 are excluded from calculation of the average standard deviation and 50% confidence limits. If no records are excluded at a given diameter, "NONE" is printed. The line printer output on pages 3 and 4 is not made if "1" is punched in column 2 of card B.

Pages 5-6: The first two lines give the general identification label IDALL and the assumed physical density RHOX. Written next are column headings for diamieter index number, diameter in micrometers, average cumulative percent mass loading less than the indicated diameter, upper 50% confidence limit of this average, and lower 50% confidence limit of this average. The latter three headings have no units. This is followed by a listing of these values for diameters ranging from 0.25 micrometer to 8.0 micrometers (unless otherwise indicated on card C). There are 28 diameters indicated over each common log cycle. The line printer output of pages 5 and 6 is not made if "1" is punched in column 2 of card B. Note that a table of outliers is not given here for mean cumulative percent mass concentration. This would be the same as given on pages 3 and 4.

Page 7: The first lines give the general identification label IDALL and assumed physical density RHOX. The column headings are then written for diameter index number, diameter in micrometers, average value of dM/dlogD at the indicated diameter in milligrams per dry normal cubic meter, the standard deviation of this average in the same units, the upper 50% confidence limit of the average in the same units, and the lower 50% confidence limits of the average in the same units. This is followed by a listing of these values for diameters ranging from 0.25 micrometer to 8.0 micrometers (unless otherwise indicated on card C). There are 14 diameters indicated over each common log cycle. The line printer output on page 7 is not made if a "1" is punched in column 2 of card B.

Page 8: After the general identification label IDALL and assumed physical density RHOX are written, column headings for interval index number, diameter in micrometers and records excluded from the mean dM/dlogD distribution are written. A table is then given showing, at diameters from 0.25 micrometer to 8.0 micrometers (unless otherwise specified on card C), the record numbers of any runs for which an outlier value of dM/dlogD was calculated. Any record numbers listed here are odd. (See discussion of pages 3 and 4 for example.) "NONE" is printed at each diameter where there are no outlier values found. The line printer output on these pages is not made if "1" is punched in column 2 of card B.

Page 9: The first two lines show the general identification label IDALL and assumed physical density RHOX. Written next are column headings for diameter index number, diameter in micrometers, average value of dN/dlogD at the indicated diameter in number of particles per dry standard cubic meter, the standard deviation of this average in the same units, the upper 50% confidence limit of the average in the same units, and the lower 50% confidence limit of the average in the same units. A listing of these values follows for diameters ranging from 0.25 micrometer to 8.0 micrometers (unless otherwise indicated on card C). Over each common log cycle, there are 14 diameters indicated. If a "1" is punched in column 2 of card B, the line printer output on page 9 is omitted.

Page 10: After the general identification label IDALL, and the assumed physical particle density RHOX are written, column headings for interval index number, diameter in micrometers, and records excluded from mean change in number size concentration are written. A table is then given showing, at diameters from 0.25 micrometer to 8.0 micrometers (unless otherwise specified on card C), the record numbers of any runs for which an outlier value of dN/dlogD was calculated. Any record numbers listed here are odd. (See discussion of pages 3 and 4 for example). "NONE" is printed at each diameter where there are no outlier values found. The line printer output is not made if "1" is punched in column 2 of card B.

Pages 11-20: Print out is given exactly as on pages 1-10 except that the assumed particle density is 1.0 gram per cubic centimeter. All averages, standard deviations, 50% confidence limits and outliers are found by making calculations on the even numbered records of files 10 and 11 ("KMC001" and "FILSPL", respectively). The listings of outliers would, of course, show even numbered records if any are excluded. For example, suppose that records 4, 10, and 16 are listed as outliers at diameter 3.27 micrometers for calculation of mean dM/dlogD (listed on page 18 of line printer output). This indicates that dM/dlogD values calculated at this diameter where unit density is assumed for runs 2, 5, and 8 are excluded from calculation of the average standard deviation, and confidence limits. If no records are excluded at a given diameter, "NONE" is printed. All statistical values (*i.e.*, all tables of averages, standard deviations, 50% confidence limits and outliers) for assumed unit density are excluded if "1" is punched in column 2 of card D.

Graph Output--

There are 8 possible graphs which may be output from program STATIS. Each shows the averaged results as described in the discussion of line printer output. For each tabular output listed in that section (except listings of outliers) there is a corresponding graph of these values. Only the diameter index number and the standard deviations are not shown on the plots. All axes have a common log scale, except for those plots of average cumulative percent mass loading less than indicated diameter vs. diameter, where the horizontal diameter axis has a common log scale and the vertical axis has a normal probability scale which shows a range of 0.01 percent up to 99.99 percent.

The plotting of results listed on pages 1-10 is controlled by code values punched on card C. A "0" punched in the proper column produces a certain plot while a "1" suppresses the plot. On card C the value punched in column 3 controls plotting of results on pages 1, 2, 5, and 6; the value punched in column 4 controls plotting of results on page 7; the value punched in column 5 controls plotting of results on page 9.

Likewise, the plotting of results listed on pages 11-20 is controlled by code values punched card E. "0" produces a graph, while "1" suppresses it. On card E the value punched in column 3 controls plotting of results on pages 11, 12, 15, and 16; the value punched in column 4 controls plotting of results on page 17; the value punched in column 5 controls plotting of results on page 19.

File Output--

One of two sequential files is used for output from program STATIS. If the program is to analyze data taken at the inlet of a gas cleaning device, *i.e.*, if "1" is punched in column 1 of card A, file number 16, which has the name "JWJ 001" is the file used. If the program is to analyze data taken at the outlet of the gas cleaning device, i.e., if "2" is punched in column 1 of card A, file number 17, which has the name "JWJ 002", is the file used.

The first group of entries made into the file are for assumed physical density. The first two of these are general information:

RHOX: This is a one-dimensional real variable requiring two words. It is the assumed particle density for the first group of entries, which is the physical density in grams per cubic centimeter.

LAS: This is a one-dimensional integer variable requiring one word. It is the number of diameter points at which average change in mass concentration is calculated.

NOTE: If statistical calculations are not desired where physical density is assumed, i.e., if "1" is punched in column 2 of card B, zeroes are written in the file "MPACFL" where RHOX and LAS are normally written. The values to be written following this begin the section of the file pertaining to unit density. (The diameter, average and standard deviation values as described below are omitted.) These zeroes are a series of "signal values" to the penetration-efficiency program PENTRA that penetration-efficiency values for assumed physical density are not to be calculated.

If RHOX and LAS are nonzero values, the entries following them are the diameter, average value of dM/dlogD at that diameter, and the standard deviation about this average. These three entries are made for each diameter analyzed. This number of diameters is LAS. The variables and number of words taken by each are as follows:

DPLOT: This is a one-dimensional real variable requiring two words. It is the diameter in micrometers at which the average dM/dlogD is being analyzed.

AVD: This is a one-dimensional real variable requiring two words. It is, in this case, the average dM/dlogD in milligrams per dry normal cubic meter, at diameter DPLOT.

SIGMA: This is a one-dimensional real variable requiring two words. It is, in this case, the standard deviation about the mean dM/dlogD in milligrams per dry normal cubic meter at diameter DPLOT.

NIN: This is a one dimensional integer variable requiring one word. It is the number of dM/dlogD values used to calculate the mean.

After the above four entries are repeated for the number of diameter sizes analyzed (LAS), a final entry is made for this assumed physical particle density:

DAST: This is a one-dimensional real variable array requiring two words. It is defined as five asterisks (*****). It is written three times and integer zero is written once as the last entry for this assumed physical density. These asterisks serve as "signal values" in the program PENTRA to indicate that all values of average dM/dlogD on record for this density have been examined.

The program now repeats the above entries beginning with assumed density RHOX (here—unit density), and number of diameters examined, LAS, for calculations. Zeroes are written in the file "MPACFL" here where RHOX and LAS are normally written if statistical calculations are not desired for assumed unit density; i.e., if "1" is punched in column 2 of card D. In this case, no further entries are made into file "MPACFL". If statistical calculations are desired ("0" punched in column 2 of card D), the values of DPLOT, AVD, SIGMA, and NIN are entered for each of the LAS diameters examined just as in the case for assumed physical particle density above. Again, the last entries are three asterisk variables, DAST, and one integer zero.

PROGRAM PENTRA

The purpose of mainline program PENTRA is to compare the differential particle size distribution (dM/dlogD) calculated at the inlet of a gas cleaning device to those calculated at the device outlet in order to find its penetration and efficiency at various specified particle sizes.

In order to execute this program, the impactor program MPPROG, the cumulative mass concentration curve fitting program SPLIN1, and the averaging program STATIS must all have been executed for both inlet and outlet data. MPPROG establishes the values of cumulative mass concentration less than stage D_{50} vs. D_{50} for each run. SPLIN1 fits a curve to these values for each run. STATIS finds the derivative of each of these curves (dM/dlogD) at specified diameters and calculates the average and standard deviation of the differential mass size distribution at these specified diameters. STATIS then records these results on the appropriate (inlet or outlet) sequential file to be used by PENTRA. PENTRA makes a "parallel" reading of both inlet and outlet sequential files (in order to read information pertaining to the same particle size). Calculations yield both a printout and a plot of the control device's efficiency (%) for the specified particle sizes.

It should be noted that in the Breakdown of Program PENTRA below, physical density is assumed to have been input to program MPPROG. This results in calculations besed on physical density and unit density (definition of aerodynamic diameter user specified) being listed alternately in output files. The user may instead desire to input only unit density to MPPROG yielding calculations based on the two different definitions of aerodynamic diameter (Mercer's[2] and Task Group on Lung Dynamics[1]).

Breakdown of Program PENTRA

026-050: Information is input here by means of the card reader. The general identification label is read in as IDGEN and contains general information concerning all runs, *e.g.*, plant site, testing dates, running condition of control device, etc. Unless otherwise specified by input here, the efficiency plot covers a range of 80.0% to 99.99%. This range is controlled by the values of YMINFR, IMIN, and IMAX. IMIN = 16 is the code value which yields a minimum limit of 80.0% on the percent efficiency grid. This requires that the minimum fractional efficiency value YMINFR = 0.800. IMAX = 25 is the code value which yields a maximum limit of 99.99% on the percent efficiency grid. Other ranges may be used if the code value ICHANGE is input as being not equal to 0.

051-060: The "Call Seek" gains access here to the two sequential files containing the inlet and outlet information to be compared for efficiency calculation. File 16 contains inlet average dM/dlogD values at specified diameters for both assumed physical density and assumed unit density. File 17 contains the same information as calculated from outlet data.

061-070: A DO-loop begins here which covers the entire program. Each pass of the loop yields a printout and plot of the penetration-efficiency characteristics at specified diameters for different assumed particle densities. In the first pass, MDEX = 1, and calculations are made for physical density. In the second pass, MDEX = 2, and calculations are made for assumed unit density.

071-088: This section checks to see if there are "complete" files of both inlet and outlet information for the assumed particle density. For example, when program STATIS is executed on outlet information, assume only aerodynamic average dM/dlogD values are calculated. This is known when, for MDEX = 1, the command to "READ(17)RHO, LAS2" yields LAS2 = 0. MDEX = 1 indicates that data for assumed physical diameter is being read. Reading file 17 indicates that outlet data is being read. LAS2 is the number of diameters examined for dM/dlogD values at the outlet. In this case, penetration-efficiency calculations cannot be made for assumed physical density. The next reading in file 17 would yield RHO and LAS2 for assumed unit density (RHO = 1.0 gram per cubic centimeter). Therefore, no further reading in file 17 should be made until MDEX = 2. Since both files 16 and 17 are sequential files, file 16 must be read to obtain all entries pertaining to physical density for inlet information. In this case, the values are read LAS1 times as dummy variables XXX, XXX, XXX, and IXX in order to keep files 16 and 17 "parallel" with one another. (If the values read are to be used, they are DPLOT, AVIN, SIGIN, AND NIN. See the discussion of cards 202-221.

089-94: NDTRI is a subroutine from the IBM 360 Scientific Subroutine Package. It takes the first argument in a fractional form and returns it in terms of the probability scale as the second argument to be used as the vertical scale for penetration-efficiency. Here, the maximum and minimum plotting limits are found. The maximum and minimum fractional limits given are 0.9999 and YMINFR (usually = 0.800), respectively. The returned probability scale equivalents are YMAX and YMIN, respectively.

095-100: The horizontal maximum and minimum plotting limits, XMAX AND XMIN, are found here in terms of the common log scale. The maximum particle diameter to be plotted is 100.0 micrometers. Thus, XMAX = $\log_{10}(100.0) = 2$. The minimum particle diameter to be plotted is 0.1 micrometer. Thus, XMIN = $\log_{10}(0.1) = -1$.

101-105: The lengths of the horizontal and vertical axes XINCH and YINCH, respectively, are established here as XINCH = 4.5 inches and YINCH = 6.5 inches. These dimensions leave adequate room for legends and a caption on an 8-1/2 inch format.

106-110: The horizontal and vertical scale factors, XS and YS, are established here in inches/user's unit:

XS = XINCH/(XMAX-XMIN), and
YS = YINCH/(YMAX-YMIN)

111-119: When program PENTRA begins execution, the plotter pen should be in its "home position", *i.e.*, on the base line of the plotter paper. This position must be defined in terms of the user's origin and stored as a reference point for the plotter. The user's origin is (XMIN, YMIN) and has values as defined above (at cards 097 and 091). The pen's "home position" is (XMIN, YO). The horizontal coordinate is the same as for the user's origin. The vertical coordinate is defined such that the user's origin is placed two inches above the "home position":

$$YO = YMIN-2/YS \qquad (247)$$

120-123: This section draws the Y-axis on the left. The call to subroutine FPLOT (0, XMIN, YMIN) moves the pen to the left side of the plot. The call to subroutine YPROB (XS, YS, XMIN, 0, IMIN, IMAX) causes the Y-axis to be drawn here beginning with the maximum efficiency to be plotted (usually 99.99% obtained by code IMAX = 25). Tick marks are drawn downward along the vertical axis to the minimum efficiency to be plotted (usually 80.0% obtained by code IMIN = 16). XS and YS are the horizontal and vertical scale factors as previously defined. XMIN is the horizontal position (on a probability scale) of the Y-axis. The fourth argument KODE = 0 indicates that the axis is to be labeled to the left of the axis.

124-131: This section labels the left Y-axis as percent efficiency. The character width and height, XCS and YCS, respectively, are each defined as 0.15 inch. The initial horizontal pen position (at base of first character) is one inch to the left of XMIN:

$$X = XMIN - 1/XS \qquad (247a)$$

The initial vertical pen position is such that the label is centered along the vertical axis:

$$Y = YMIN + (YMAX-YMIN)/2 - (9)(XCS)/YS \qquad (248)$$

The angle of writing is PI/2 where PI = 3.1415. The plotter is prepared for writing the label by the call to FCHAR (X, Y, XCS, YCS, PI/2.), and the write command prints "PERCENT EFFICIENCY" along the left vertical axis.

132-137: This section draws the X-axis. This axis is drawn as a common log scale. The call to plotter subroutine XSLBL (XS, YS, XMIN, YMIN, IXRAN, XMIN) labels the X-axis for the $\log_{10}$ scale. The call to plotter subroutine XLOG (XS, YS, XMAX, YMIN, -1, IXRAN) drawn the X-axis scale. (It is drawn from (XMAX, YMIN) to the left since the fifth argument = -1.).

138-142: This section labels the X-axis as "PARTICLE DIAMETER (MICROMETERS)". The initial horizontal pen position, X, for describing the horizontal axis is defined so that the writing is centered along the horizontal axis:

$$X = XMIN + (XMAX-XMIN)/2 - (16)(XCS)/XS \qquad (249)$$

The initial vertical pen position Y is located far enough below the X-axis (0.7 inch) that the height of written characters does not interfere with the drawn axis:

$$Y = YMIN - 0.7/YS \qquad (250)$$

The call to plotter subroutine FCHAR (X,Y,XCS,YCS, 0.) gives the initial pen coordinates (X,Y) and the character width and height, XCS and YCS, and the angle for writing in radians, 0.0. This prepares the plotter for the command to write "PARTICLE DIAMETER (MICROMETERS)" along the horizontal axis.

143-151: This section draws the Y-axis on the right of the plot using a probability scale and labels it "PERCENT PENETRATION". The commands here are very similar to those at cards 120-131 except that the axis labelling is made to the right of the axis (fourth argument of YPROB is nonzero, here = 1). The range of the plot is usually 0.01 at YMAX to 20.0 at YMIN. This is the result if code variables IMIN and IMAX are input as 16 and 25, respectively. The range may be altered by different input for IMIN and IMAX.

152-160: A general heading of "PENETRATION-EFFICIENCY" is written above the graph in this section. The character width and height, XCS and YCS, are each defined as 0.12 inch. The beginning horizontal pen position X is such that the heading is centered over the graph:

$$X = XMIN + (XMAX-XMIN)/2 - (11)(XCS)/XS \qquad (251)$$

The beginning vertical pen position Y causes the heading to be written 0.75 inch above the graph:

$$Y = YMAX + 0.75/YS \qquad (252)$$

The writing is to be made at an angle of 0.0 radians. The call to plotter subroutine FCHAR (X,Y,XCS,YCS,0.) prepares the plotter for the command to write "PENETRATION-EFFICIENCY".

161-178: This section writes the general identification label IDGEN and density RHO above the plot (beneath "PENETRATION-EFFICIENCY"). IDGEN is written with an initial pen position (X,Y) such that X = XMIN (in line with the left vertical axis) and Y = YMAX + 0.5/YS or 0.5 inch above the plot. This is low enough not to interfere with the "PENETRATION-EFFICIENCY" heading since the characters are small. They have a width and height in inches of:

XCS = 0.056, and
YCS = 0.100

The DO-loop at cards 166-169 finds the last character of the IDGEN array and labels it as IDGEN (J). This prevents undue pen movement in writing the identification label. The initial pen position (X,Y) for writing the density is, again, in line with the left vertical axis and 0.25 inches above the graph:

X = XMIN, and
Y = YMAX + 0.25/YS

Character width, height and angle of writing are the same as for writing IDGEN.

179-181: These statements write the general identification label IDGEN and assumed density RHO at the top of a page on the line printer. (Percent efficiency characteristics will follow on that same page.)

182-186: A statement here writes the column headings "INTERVAL", "DIAMETER", "AVERAGE EFFICIENCY", "UPPER CONFIDENCE LIMIT OF EFFICIENCY", and "LOWER CONFIDENCE LIMIT OF EFFICIENCY" on the same page as above.

187-189: ISIG is a code variable whose value indicates when the end of entries pertaining to the given assumed particle density for inlet data has been reached. ISIG is initialized as 0 here. ISIG = 1 when all entries pertaining to the given assumed density for inlet data have been read. KSIG is this same code variable as applied to the reading of outlet data entries.

190-201: The loop begins here which calculates the percent efficiency and confidence limits for each specified diameter. The index of the loop, NSLOT, is the diameter index number. RSLOT is this same index as a real number. For the diameter indicated by NSLOT, the average efficiency, AVEFF, upper confidence limit of efficiency, CLUE, and lower confidence limit of efficiency. CLLE, are all initialized as 0.0. Also, the average penetration, AVPEN, upper confidence limit of penetration, CLUP, and lower confidence limit of penetration, CLLP, are all initialized as 1.0. NCON is a code variable whose value indicates whether or not limits are to be calculated and drawn. It is initialized here as 0. If the average inlet change in mass size concentration = 0, confidence limits cannot be calculated and the value of NCON is changed to 1.

202-221: Parallel entries of the inlet file (file 16) and outlet file (file 17) are read. By "parallel" here is meant that the entry read from each file concerns the same diameter. From file 16 is read the diameter, DPLOT, average dM/dlogD at the inlet for this diameter, AVIN, the standard deviation about the average SIGIN, and number of dM/dlogD values used in calculating AVIN and SIGIN, NIN. From file 17 is read the diameter, DPLOT, dM/dlogD at the outlet for this diameter, AVOUT, the standard deviation about this average, SIGOUT, and number of dM/dlogD values used in calculating AVOUT and SIGOUT, NOUT. When the end of the file has been reached for entries for this assumed density, the value of DPLOT is DAST, which is five asterisks. With this "flag", the code variable for this file which signals the end of entries for this assumed density (ISIG for file 16, KSIG for file 17) is set equal to 1. If this end is reached for one file before the other, reading of the longer file continues without calculation of efficiency for these larger diameters.

222-242: If entries are read for both inlet (DPLOT, AVIN, SIGIN, and NIN) and outlet (DPLOT, AVOUT, SIGOUT, and NOUT), the program comes to statement 210 (card 222). All penetration-efficiency and confidence limits calculations are made here. If the average inlet dM/dlogD at this diameter AVIN is nonpositive, or if the number of inlet dM/dlogD values, NIN, or the number of outlet dM/dlogD values for this diameter is zero, no calculations are made in this section. The variables keep their initialized values (see discussion of cards 190-201), the code variable NCON is set equal to 1 to indicate that there are no confidence limits, and the program skips out of this section to statement 50 (card 246). Otherwise, the average fractional penetration, AVPEN, at this diameter is calculated as a function of the average inlet dM/dlogD at this diameter, AVIN, and the average outlet dM/dlogD at this diameter, AVOUT:

$$\text{AVPEN} = \text{AVOUT}$$

The average fractional efficiency, AVEFF, is then:

$$\text{AVEFF} = 1.0 - \text{AVPEN}$$

In order to calculate 50% confidence intervals, the Student's t-distribution multiplier must be determined for the number of samples taken at the outlet, NOUT, and inlet, NIN. These t-distribution values are calculated at card 230 for the outlet and card 231 for the inlet. The square of the confidence interval, SIGIO, is calculated at cards 232-233. SIGIO is a function of the standard deviation of the outlet dM/dlogD at this diameter, SIGOUT; the average inlet dM/dlogD at this diameter, AVIN; the average fractional penetration at this diameter (as found above), AVPEN; the standard deviation of the inlet dM/dlogD at this diameter, SIGIN; the number of outlet dM/dlogD values used to calculate AVOUT and SIGOUT, NOUT; the number of inlet dM/dlogD values used to calculate AVIN and SIGIN, NIN; and the t-distribution values for the outlet and inlet, TOUT and TIN:

$$\text{SIGIO} = (\text{AVPEN})^2 \left\{ \frac{\left[\text{TOUT}\ \frac{\text{SIGOUT}}{\text{AVOUT}}\right]^2}{\text{NOUT}} + \frac{\left[\text{TIN}\ \frac{\text{SIGIN}}{\text{AVIN}}\right]^2}{\text{NIN}} \right\} \quad (253)$$

If SIGIO is a positive number, the square root is taken and confidence limits determined.

The upper and lower confidence limits of the fractional penetration, CLUP and CLLP, respectively, may be calculated as:

$$\mathrm{CLUP = AVPEN + (SIGIO)^{\frac{1}{2}}}$$

$$\mathrm{CLLP = AVPEN - (SIGIO)^{\frac{1}{2}}}$$

The upper and lower limits for fractional efficiency, CLUE and CLLE, respectively, are then:

$$\mathrm{CLUE = 1.0 - CLLP}$$

243-254: This begins the section for plotting percent penetration and percent efficiency vs. $\log_{10}$ diameter. The diameter DPLOT is first converted to its plotted common log form. The subroutine XVAL (DPLOT, XMAX, XMIN, XS) checks the variable DPLOT to see if it lies between the horizontal plotting bounds XMAX and XMIN. If so, its value is not changed, and XVAL = DPLOT. If DPLOT falls beyond one of these bounds:

$$\mathrm{XVAL = DPLOT + 0.15/XS} \qquad \mathrm{DPLOT > XMAX}$$

or

$$\mathrm{XVAL = DPLOT - 0.15/XS} \qquad \mathrm{DPLOT < XMIN}$$

In such a case, the diameter coordinate has a value 0.15 inch beyond the exceeded bound. The horizontal coordinate variable to be plotted, XN, is set equal to the result of function XVAL.

254-284: If confidence limits have been calculated, *i.e.*, NCON ≠ 1, the plotted probability YV, which corresponds to the lower confidence limit of fractional efficiency, CLLE, is calculated in this section. First, CLLE is checked to see if it falls within the range of 0.0001 to 0.0000. If CLLE < 0.0001, YV is given an arbitrary value of -4. (This might be any number < -3.7191244 which is the probability equivalent for a fractional efficiency of 0.0001.) If CLLE > 0.9999, YV is given an arbitrary value of +4. (This might be any number > +3.7191244 which is the probability equivalent for a fractional efficiency of 0.9999.) Unless CLLE lies outside the bounds 0.0001 to 0.9999, the value of its equivalent probability variable, YU is found by the subroutine NDTRI (CLLE, YV, D, IE). The probability variable YV is then checked by the function YVAL (YV, YMAX, YMIN, YS) to see if it is within the vertical plotting limits, YMAX and YMIN. If YMAX ≤ YV ≤ YMIN, YVAL = YV. If YV < YMIN, YVAL is given a value which falls 0.15 inch to the left of the minimum boundary, or YVAL = YV - 0.15/YS. If YV > YMAX, YVAL is given a value which falls 0.15 inch to the right of the maximum boundary, or YVAL = YV + 0.15/YS. The vertical coordinate variable to be plotted, YN, is set equal to the result of function YVAL. Recall that the horizontal coordinate variable XN is the result of a similar testing function XVAL. See discussion of cards 243-253.

284-288: This section draws a horizontal tick mark 0.06 inch long for the lower 50% confidence limit at the indicated diameter. The plotter subroutine FPLOT (I, XN, YN) controls movement of the pen.

289-303: The value of the probability variable YV is found here for the average fractional efficiency at this diameter, AVEFF, in the same manner as for the lower 50% confidence limit of efficiency, CLLE, as discussed for cards 254-283. The variable to be plotted, YN, is again the result of the testing function YVAL.

304-306: The pen is moved by the plotter subroutine FPLOT (0, XN, YN) to the average efficiency value on the probability scale. If the lower 50% confidence limit has been drawn, this movement draws the bar from this point to the average. Otherwise, the pen is in the up position when moved to the average (no bar drawn) and the pen must be lowered by calling FPLOT (2, XN, YN).

307-311: The call to subroutine SYMBOL (9, 0.04) draws a solid circle 0.04 inch in diameter for average fractional efficiency at this diameter.

312-330: If 50% confidence limits have not been calculated and therefore are not to be shown on the plot, *i.e.*, if NCON is positive, the pen is raised by the call FPLOT (1, XN, YN). In this case the program skips to statement 55 (card 342) and omits the plotting of the upper 50% confidence limit of efficiency, CLUE. Otherwise, the value of the probability variable YV is found here for the upper 50% confidence limit of fractional efficiency at this diameter, CLUE, in the same manner as for the lower 50% confidence limit of efficiency, CLLE, as discussed for cards 254-283. The variable to be plotted, YN, is the result of the testing function YVAL.

331-336: The pen is moved from the point of average fractional efficiency to the upper 50% confidence limit. There it makes a horizontal tick mark 0.06 inch long. The pen is then raised so that it is ready for plotting the average efficiency and confidence limits at the next diameter. All pen movement is controlled by the plotter subroutine FPLOT.

337-345: The diameter index number RSLOT, the particle diameter DPLOT, the average fractional efficiency at this diameter AVEFF, the upper 50% confidence limit of this average, CLUE, and the lower 50% confidence limit of this average CLLE were set equal to $RBUF_1$, $RBUF_2$, $RBUF_3$, $RBUF_4$, and $RBUF_5$, respectively, by an equivalence statement. Here a

DO-loop converts average fractional efficiency and upper and lower 50% confidence limits of fractional efficiency at this diameter to percentages. Any of these values > 100% is given a value of 100%. Any of these values < 0% is given a value of 0%.

346-349: For printing purposes, the $\log_{10}$ diameter variable DPLOT (used for plotting diameter) is converted back to its original antilog value. DPLOT is now the diameter.

350-354: The diameter index number NSLOT (or $RBUF_1$), the diameter in micrometers DPLOT (or $RBUF_2$), the average percent efficiency at this diameter AVEFF (or $RBUF_3$), the upper 50% confidence limit of the percent efficiency (or $RBUF_4$), and the lower 50% confidence limit of the percent efficiency (or $RBUF_5$) is output on the line printer here. The program then returns to the top of the loop at card 193 to repeat all calculations and output for the next diameter.

355-362: When the average efficiency and confidence limits have been found for all specified diameters for this assumed density (physical when MDK = 1, unit when MDK = 2), the plotter pen is returned to its "home position" on the baseline of the plotter paper 4.5 inches beyond the maximum horizontal axis limit XMAX. The pen is now in the proper position for any future plots. Statement 200 (card 362) ends the large loop which began at card 061 which makes all efficiency calculations for one assumed density. If this is the end of the first traverse of the loop, *i.e.*, MDK = 1 for efficiency calculations where physical density is assumed, then the program returns to the top of the loop, MDK = 2, and all efficiency calculations are made for an assumed unit density. If this is the end of the second traverse of the loop, the program ends.

Functions of the Called Subroutines

Subroutine NDTRI (P, X, D, IE)--

This is an IBM 360 Scientific Subroutine Package subroutine. Its first argument P is given as a fraction ideally between 0.001 and 0.9999. A value based on a conversion to the probability scale is returned as the second argument X. Since this subroutine is called by more than one program, details of NDTRI may be found in the section on "General Subroutines and Functions".

Subroutine YPROB (XS, YS, XLIM, KODE, IMIN, IMAX)--

This is a subroutine written by R. W. Gaston, 1975, which draws and labels left (for KODE = 0), or right (for KODE = 1) Y-axes for normal probability scale. This subroutine also is called by more than one program. Details of YPROB may be found in the section on "General Subroutines and Functions".

Input to Mainline Program PENTRA

Card Input--

A general identification is input to the program which heads both graph and line printer output. Also, the plotting range is input according to code values.

Card A: This card gives the general identification label in columns 1-80. It is read by an 80A1 format and may contain such information as testing location, dates, conditions of control device operation, etc.

Card B: A code value in columns 1 and 2 indicates whether the internally determined probability plotting range is to be used or whether further cards are to be read to specify a different range.

Columns 1-2: Punch zeroes here (or leave blank) if the internally specified probability plotting minimum of 80% for percent efficiency is to be used. This yields a percent penetration maximum of 20%. If another minimum percent is desired, punch any one or two digit nonzero number here.

Card C: This card is included only if a minimum percent efficiency other than 80% is desired (*i.e.*, if card B is punched with a nonzero number). A code value is punched here which indicates the minimum fractional efficiency limit to be plotted.

Columns 1-2: Punch the integral code value corresponding to the desired minimum fractional efficiency plotting limit using an I2 format. (See Table 14.)

Card D: This card is included only if a minimum percent efficiency other than 80% is desired (*i.e.*, if card B is punched with a nonzero number). The minimum fractional efficiency for plotting is punched on this card.

Columns 1-5: Punch the minimum fractional efficiency limit for plotting using F5.4 format.

File Input--

The two random access files 16 and 17 under the names "JWJ001BIN" and "JWJ002BIN", respectively, are used by program PENTRA. Both of these files are the result of the execution of program STATIS. File 16 contains the results of inlet data reduction, and file 17 contains the results of outlet data reduction. The first record of each of these files contains the following entries:

RHO: This is a real variable requiring two words. It is the physical density in grams per cubic centimeter. It is the assumed density for the data to follow.

TABLE 14. RELATIONSHIP BETWEEN IMIN AND THE CORRESPONDING MINIMUM FRACTIONAL EFFICIENCY

IMIN	Corresponding minimum fractional efficiency
1	0.0001
2	0.0005
3	0.0010
4	0.0020
5	0.0050
6	0.0100
7	0.0200
8	0.0500
9	0.1000
10	0.2000
11	0.3000
12	0.4000
13	0.5000
14	0.6000
15	0.7000
16	0.8000
17	0.9000
18	0.9500
19	0.9800
20	0.9900
21	0.9950
22	0.9980
23	0.9990
24	0.9995

LAS1 (if read from inlet file 16) or
LAS2: (if read from outlet file 17) - This is an integer requiring one word. It is the number of diameters at which the average dM/dlogD has been calculated. This is then also the number of records to be read where physical density is assumed.

LAS1 or LAS2 records follow this first record with the following entries:

DPLOT: This is a real variable requiring two words. It is the diameter at which the average dM/dlogD was calculated for this record.

AVIN (if read from inlet file 16) or
AVOUT: (if read from outlet file 17) - This is a real variable requiring two words. It is the average change in dM/dlog at diameter DPLOT.

SIGIN (if read from inlet file 16) or
SIGOUT: (if read from outlet file 17) - This is a real variable requiring two words. It is the standard deviation about the specified average change in dM/dlogD.

NIN (if read from inlet file 16) or
NOUT: (if read from outlet file 17) - this is an integer variable requiring one word. It is the number of dM/dlogD values used in finding the average and standard deviation.

The final record for this assumed density (unless LAS1 = 0, if read from inlet file 16 or LAS2 = 0, if read from outlet file 17) is three groups of five asterisks followed by 0 or DAST, DAST, DAST, IBLAK where DAST = ***** and IBLAK = 0. These values have been written instead of DPLOT, AVIN (AVOUT), SIGIN (SIGOUT), and NIN (NOUT) to flag the end of records for assumed physical density for the inlet (outlet).

The second half of files 16 and 17 consists of the same entries as in the first half except that RHO is now 1.0 gram per cubic centimeter. All values loaded in the records to follow are the results of data reduction where unit density is assumed.

Output from Mainline Program PENTRA

Line Printer Output--

Two pages of output are given by program PENTRA. The first page shows the general identification label (as input to the program by card read) and the assumed physical density. This is followed by a table listing the diameter index number, the diameter in micrometers, the average percent efficiency, the upper 50% confidence limit of this efficiency, and the lower 50% confidence limit of this efficiency. The second page shows the general identification label and the assumed unit density, 1.0 gram per cubic centimeter. A table follows giving the same type of listings as for physical diameter calculations.

Graph Output--

Two graphs are output by this program—the first for assumed physical density, the second for assumed unit density. Each is a plot of percent efficiency for the gas cleaning device vs. particle diameter in micrometers. The grid is a probability scale vs. common log scale. Each plot also has a vertical probability scale on the right side for percent penetration.

File Output--

None.

PROGRAM PENLOG

The purpose of mainline program PENLOG is the same as that of mainline program PENTRA, i.e., to compare differential size distributions calculated for the inlet and outlet of a control device in order to obtain penetration-efficiency information for various particle sizes. As with program PENTRA, the execution of mainline programs MPPROG, SPLIN1, and STATIS is required for both inlet and outlet data before PENLOG may be executed.

PENLOG differs from PENTRA in input and output format. The set range for efficiency is from 90% to 99.99% and therefore 0.01% to 10.0% for penetration. Thus, there is no option to read in a minimum value for the efficiency axis. The graphical output of PENLOG yields a common log scale for both penetration and efficiency, rather than the log probability scale produced by PENTRA. Line printer output is the same for both programs.

Since the PENLOG and PENTRA programs are so nearly alike, the reader should refer to the Breakdown of Program PENTRA for explanation of PENLOG, except for the points noted here.

1. Variables IMIN, IMAX, and YMINFR are not initialized.
2. The option to change the range of the penetration-efficiency graph has been omitted, i.e., code variable ICHRAN is not read in and consequently values for IMIN and YMINFR are also not read into the program. The option to plot or suppress confidence limits is preserved. Therefore, NSPCON is still read in an I1 format.
3. The maximum and minimum penetration values are set at $\log_{10}(10.0)$ for 10% and $\log_{10}(0.01)$ for 0.01%. Thus, subroutine NDTRI is not called to find maximum and minimum efficiency values.

4. The y-axes for penetration and efficiency are interchanged. Penetration is on the right, efficiency is on the left.

5. The penetration and efficiency axes are obtained by plotter subroutines YLOG and LGLBL to set up a common log scale, rather than using subroutine YPROB, as in PENTRA, to set up a log probability scale.

6. Logarithms of the average penetration and the associated confidence intervals are plotted at each diameter. This differs from PENTRA where a log probability scale is used. Penetration values are checked to determine if they lie in the range of 0.0001 to 0.10. Values not in this range are plotted slightly above or slightly below the set maximum or minimum values.

GENERAL SUBROUTINES AND FUNCTIONS

The following subroutines and functions are called by more than one of the mainline programs discussed in this section.

Subroutine SYMBOL (KODE, SIZE)

Subroutine SYMBOL (KODE, SIZE) draws a symbol whose shape is determined by the value of the variable KODE and whose size is determined by the value of the variable SIZE. The eleven symbols drawn are listed here with respect to the value of KODE:

KODE	Symbol drawn
1	Square
2	Triangle
3	Circle
4	+
5	X
6	✳ (+ over X)
7	Solid square
8	Solid triangle
9	Solid circle
10	Diamond
11	Solid diamond

Of course, various other symbols are possible by calling this subroutine more than once to superimpose symbols. SIZE is the length in inches of the side of a square which would enclose the symbol. Subroutine SYMBOL leaves the pen in the same position as when the subroutine is called.

Breakdown of Subroutine SYMBOL--

036-037: The arithmetic function RND (XX) is defined so that the argument XX is rounded to a higher value by adding 0.5 to the value of XX if XX is positive, or XX is rounded to a lower value by subtracting 0.5 from the value of XX if XX is negative.

038-039: IXZ2 is defined here as an integer equal to half the length of one side of the enclosing square in hundredths of an inch. The rounding function has the effect of rounding to the next higher size in hundredths of an inch in case SIZE is specified more exactly than hundredths of an inch. (The smallest pen movement is 1/100 inch.)

040: SIZE1 (real value) and ISZ (interger value) are both the length of the enclosing square in hundredths of an inch (SIZE, on the other hand, is in inches).

041-043: These three logic tests check for out of range values of KODE, SIZE, and ISZ2. If an out of range value is found, SYMBOL returns to the calling program without plotting.

044: ISTRT is the initial value of the DO-loop index which draws the symbols (except the circle) beginning at statement 550 (card 118). It is initialized here as 1. ISTRT remains = 1 for the drawing of +, X, or *. Other symbols begin the 550 DO-loop with ISTRT = 2.

045-047: (IX1, IY1) is the beginning pen location for the drawing of +, X, and * and is defined as (0,0). (IX6, IY6) is the beginning pen position, relative to (0,0) for the drawing of the square and the triangle. It is defined as (ISZ2, -ISZ2). Figure 3 shows these pen locations relative to the initial pen position and the enclosing square.

048-049: The read statement to the plotter (device 7) defines the previous pen position, the absolute position of the pen when SYMBOL is called, as

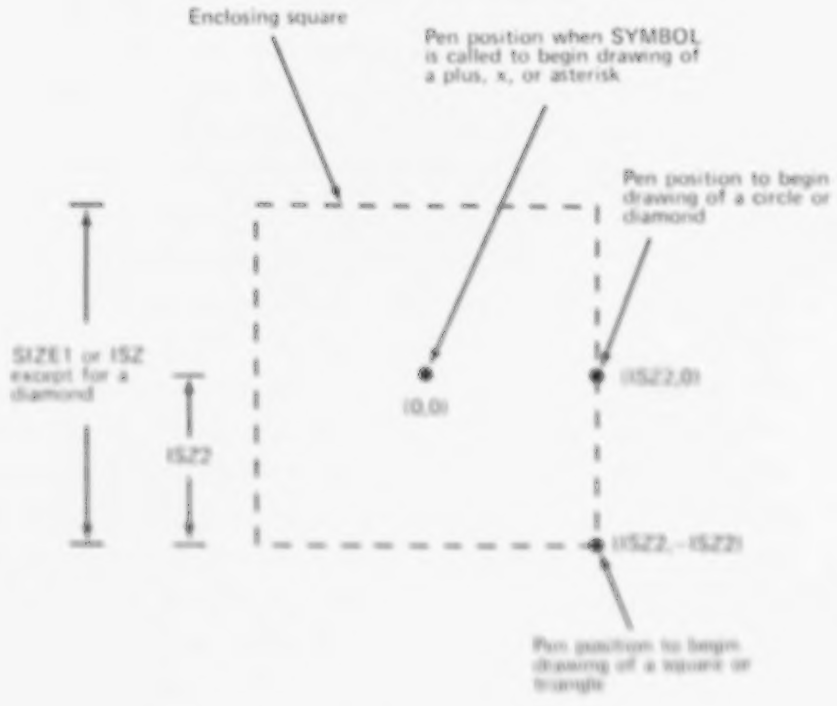

Enclosing square
Pen position when SYMBOL is called to begin drawing of a plus, x, or asterisk
Pen position to begin drawing of a circle or diamond
SIZE1 or ISZ except for a diamond
ISZ2
(0,0)
(ISZ2,0)
(ISZ2,−ISZ2)
Pen position to begin drawing of a square or triangle

Figure 3. Beginning pen position for drawing of figures relative to pen position at call to SYMBOL. The enclosing square is shown with dashed lines.

(LASTX,LASTY), the last character sizes IX2 and IX3 (dummy variables here, not used), the last sine and cosine of the character sizes IX2 and IX3 (dummy variables here, not used), the last sine and cosine of the character angle IX3 and IX4 (dummy variables here, not used), and the pen position code IPEN. If the pen is up IPEN = 0, if down IPEN = 100000. These are octal numbers.

050-053: Except for the symbols +, X, and *, the pen must begin the drawing in a position other than its original position, and the starting code value for the drawing loop index is defined as ISTRT = 2. If a square or triangle is to be drawn (KODE = 1, 2, 7, or 8), the beginning pen position, (IX6, IY6), is as defined above at (ISZ2, -ISZ2). This is in the lower right-hand corner of the enclosing square. If a circle or a diamond is to be drawn (KODE = 3, 9, 10, or 11), the beginning pen position, (IX6, IY6), is defined as (ISZ2, 0) so that the pen is in the middle of the right side of the square. These relationships are shown in Figure 3. The pen is then moved by the write statement to the ploter (device 7) using mode 4 which has the function of moving the pen in the up position to a new set of coordinates. The change in coordinates here is (IX6, IY6) as defined above according to the valu of KODE.

054: Each chage in coordinates must be defined for the pen moveents which produce the indicated symbol. Therefor, the program skips to the proper section dependin on the value of KODE. Note that KODE = 4, 5, an 6 are dummy directions since the program would have already proceeded to statement 400 or 500 to daw a +, X, or *.

055-063: The drawing of a square is discussed here. Four pen movements are needed to draw the square. Since the beginning loop index has been defined as ISTRT = 2, the ending loop index is defined as IEND = 5. The pen begins at (ISZ2,-ISZ2) relative to the original pen position when SYMBOL is called. (IX2, IY2) through (IX5, IY5) are defined as the changes in coordinates at each pen movement. These are not absolute coordinate values, but changes relative to last pen position. Figure 4 shows the four pen movements and the change in coordinates for each movement. The program goes to statement 550 (card 118) to draw the square.

064-073: The drawing of a triangle is discussed here. Three pen movements are needed to draw the triangle. Since the beginning loop index has been defined as ISTRT = 2, the ending loop index is defined as IEND = 4. Changes in pen coordinates (IX2, IY2) through (IX4, IY4) are defined here. These are not absolute coordinate values, but changes relative to last pen position. Figure 5 shows the three pen movements and the change in coordinates for each movement.

074-091: This section draws the circle symbol. Other symbols are drawn at the DO-loop beginning at statement 550, card 118. The circle begins at the point ISZ2 which is half the width of the enclosing square. Initial movement is horizontal from the point at which subroutine SYMBOL is called, LASTX, LASTY). The angle here, THETA, is initiallized as 0.0 radians. The last angle to which the pen will move, THLAST, is defined as 2π radians = 6.283185 radians. The angle increment through which the pen moves at each WRITE state-

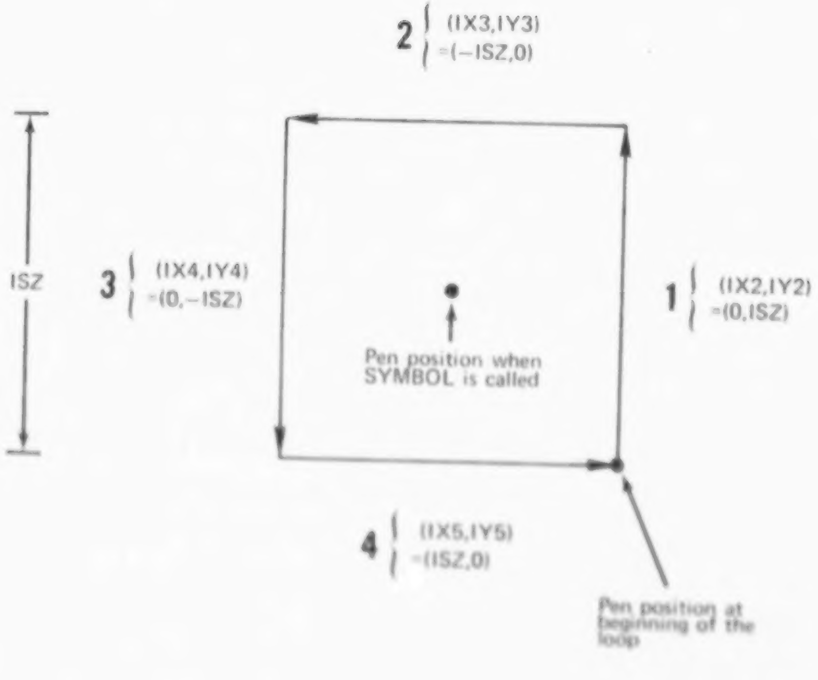


Figure 4. Pen position changes to draw a square.

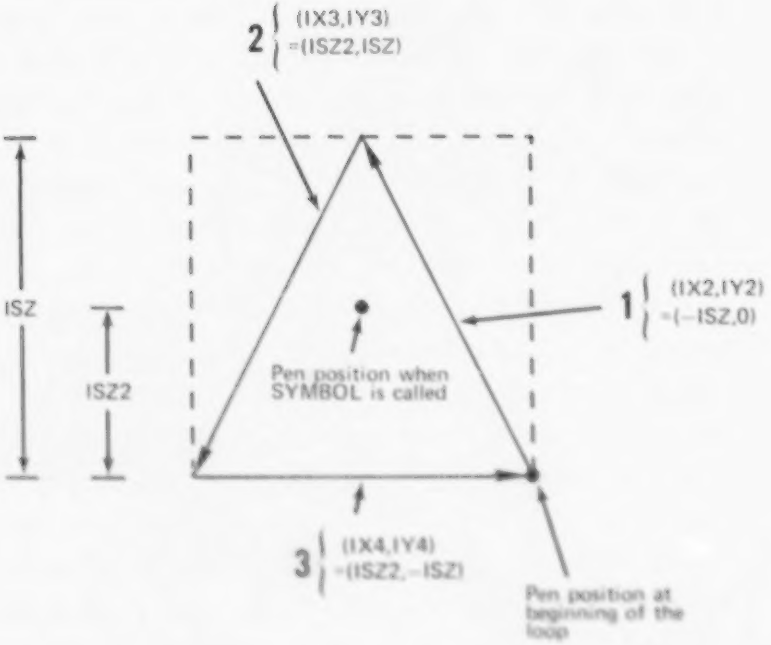


Figure 5. Pen position changes to draw a triangle.

ment, THINC, is defined as 2.0/SIZE1 radians. Note that this is inversely proportional to the dimension of the square, SIZE1. Thus, even for a large circle, each pen movement is small so that the result appears as a circle rather than a polygon. Statement 325 (card 82) begins an implied DO-loop which sets up the coordinate increments, IX1 and IY1, the new coordinates, (IX2, IY2), and moves the pen from point to point at each traverse, thus, drawing the circle. Note that the increments IX1 and IY1 are defined as changes relative to the original position of the pen, (LASTX, LASTY). The original pen location is the point around which the circle is being drawn. IX2 and IY2 are absolute coordinates and not changes in coordinates. Figure 6 shows the pen positions and changes in coordinates. Since the coordinates are absolute values, the write statement to the plotter uses mode 3, as opposed to mode 5, which moves by changes in delta coordinates. Delta coordinates are coordinates referred to the last pen location. These options are explained in Appendix A, DEC PDP - 15/76 Plotter Subroutines in the section entitled "Unichannel XY Plotter Handler". After each pen movement, the angle THETA is incremented by THINC and tested to see if the circle has been completed (THETA > THLAST). If not, the subroutine returns to statement 325 (card 82) to continue drawing. If the circle has been completed and only a "hollow" circle is desired (KODE = 3), the subroutine skips to statement 750 where the pen is raised and moved to the center of the circle (LASTX, LASTY). There the original pen position (when subroutine SYMBOL was called) is checked,

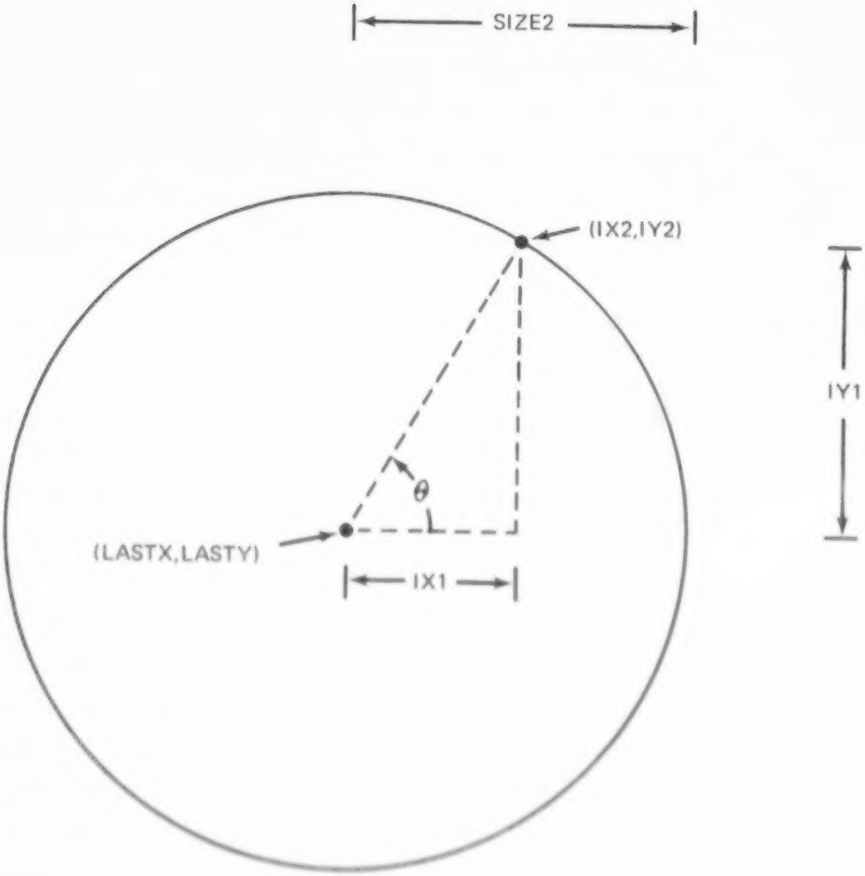
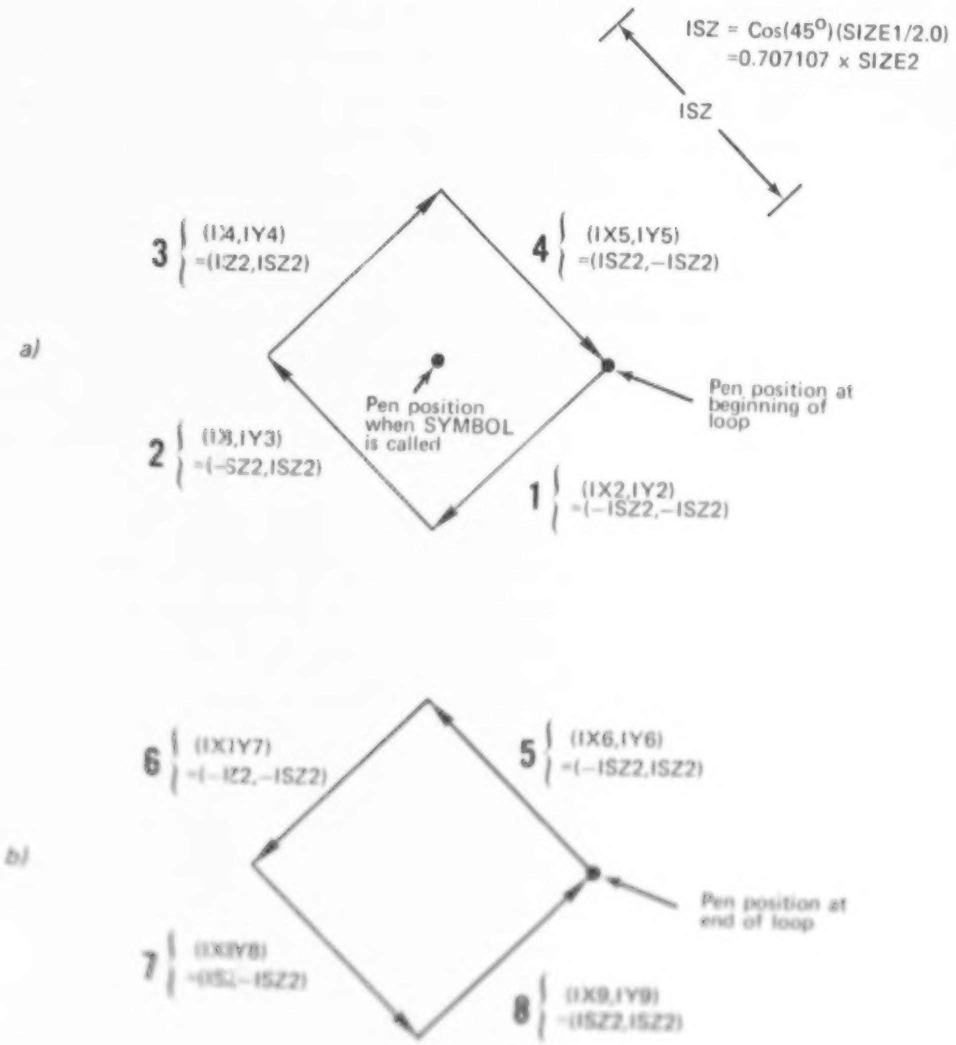


Figure 6. Pen positions for drawing of a circle are defined as functions of the pen position when SYMBOL is called. These are (LASTX,LASTY) and the circle radius, SIZE2.

and the pen is put back into this position, up or down, before returning to the calling program. If a solid circle is desired (KODE = 9), the dimension of the enclosing square SIZE1 is decreased by 2/100 inch and a slightly smaller circle is drawn inside the first. This process continues until the original circle is filled in. The subroutine then skips to statement 800 (card 146) where the pen is placed into the same up or down position as when SYMBOL was called. Then SYMBOL returns to the calling program. Note that the pen is already in the center of the circle at (LASTX, LASTY) and it is not necessary to go to statement 750 to move it there.

092-100: The series of changes in position for the drawing of a diamond is discussed here. Only four pen movements are needed to draw a diamond. However, since all pen movements are in 1/100-inch vertical and horizontal pen movements, a small diamond does not have smoothly drawn sides. Therefore, a diamond is drawn again superimposed over the first to "smooth" the diamond. Eight pen movements are then needed. The loop at statement 550 (card 118) has a beginning index value ISTRT = 2. Therefore, the last index value is defined here as IEND = 9. The pen begins at (ISZ2,0) relative to the original pen position when SYMBOL is called. (IX2, IY2) through (IX9, IY9) are defined as the changes in coordinates for each pen movement (not absolute coordinate values). Figure 7 shows the eight pen movements and the change in coordinates for each movement. The program then goes to statement 550 to draw the diamond.



ISZ = Cos(45°)(SIZE1/2.0)
=0.707107 x SIZE2
ISZ
3 (IX4,IY4) =(ISZ2,ISZ2)
4 (IX5,IY5) =(ISZ2,−ISZ2)
a)
Pen position when SYMBOL is called
Pen position at beginning of loop
2 (IX3,IY3) =(−SZ2,ISZ2)
1 (IX2,IY2) =(−ISZ2,−ISZ2)
6 (IXIY7) =(−IZ2,−ISZ2)
5 (IX6,IY6) =(−ISZ2,ISZ2)
b)
Pen position at end of loop
7 (IX8IY8) =(ISZ,−ISZ2)
8 (IX9,IY9) =(ISZ2,ISZ2)

Figure 7. Penposition changes to draw a diamond for: a) a loop ind of 2 (ISTRT) through 5; b) a loop index of 6 thrgh 9 (IEND).

101-108: The series of pen changes for drawing the symbol + is discussed here. Eight pen movements are used to draw this symbol. Since the beginning loop index value has been defined as ISTRT = 1, the ending loop index value is defined as IEND = 8. The drawing begins with the pen in its original position when subroutine SYMBOL is called. (IX1, IY1) through (IX8, IY8) are defined here as the changes in coordinates at each pen movement. These are not absolute coordinate values, but are the "Delta" coordinate values mentioned above. Figure 8 shows the eight pen movements and the change in coordinates for each movement. The program goes to statement 550 (card 118) to draw the +.

109-114: The series of pen changes for drawing the symbol X is discussed here. Eight pen movements are used to draw this symbol. Since the beginning loop index value has been defined as ISTRT = 1, the ending loop index is defined as IEND = 8. Drawing begins with the pen in its original position when subroutine SYMBOL is called. (IX1, IY1) through (IX8, IY8) are defined as the changes in coordinates at each pen movement. These are not absolute coordinate values, but "Delta" coordinate values mentioned above. Figure 9 shows the eight pen movements and the change in coordinates for each movement. The program goes to statement 550 (card 118) to draw the X.

115-120: The DO-loop here draws all symbols except the circle. (See cards 074-091 for drawing a circle.) Coordinate changes have been defined previously for each possible symbol. The beginning and ending loop index values ISTRT and IEND, have also

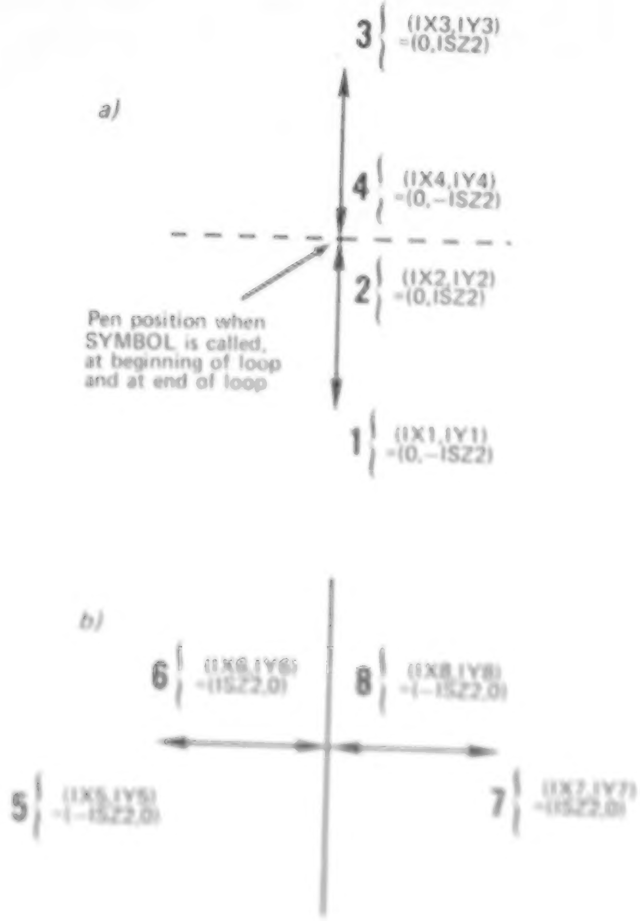


Figure 8. Pen position changes to draw a plus for: a) a loop index of 1 (ISTRT) through 4; b) a loop index of 5 through 8 (IEND).

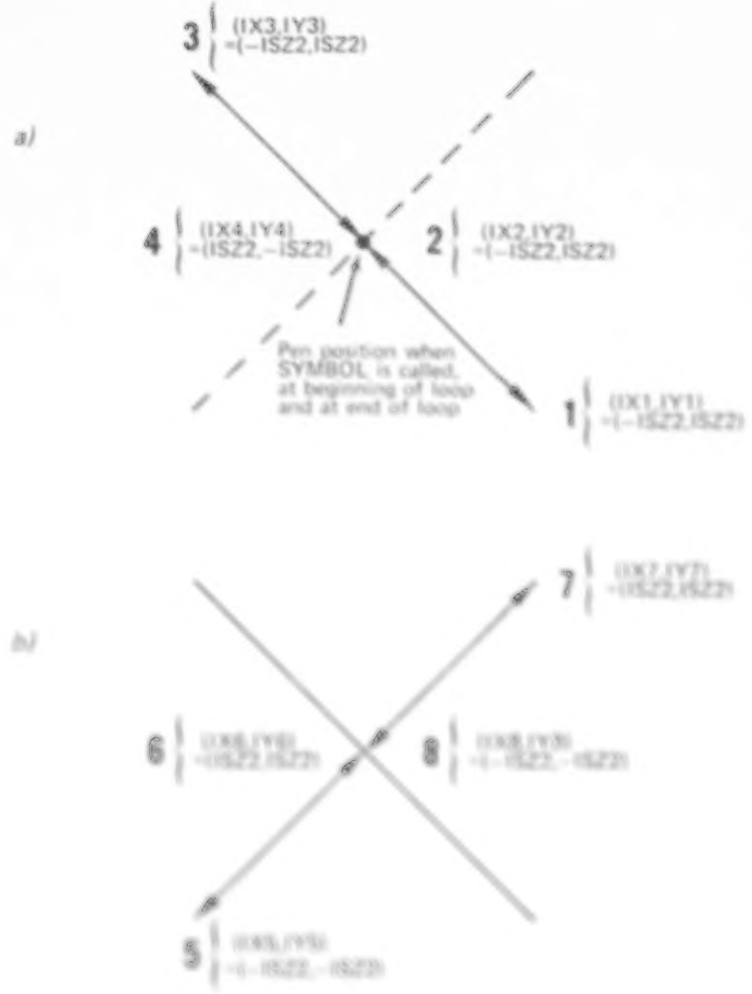

a)
3 (IX3,IY3) =(−ISZ2,ISZ2)
4 (IX4,IY4) =(ISZ2,−ISZ2)
2 (IX2,IY2) =(−ISZ2,ISZ2)
Pen position when SYMBOL is called, at beginning of loop and at end of loop
1 (IX1,IY1) =(−ISZ2,ISZ2)
b)
7 (IX7,IY7) =(ISZ2,ISZ2)
6 (IX6,IY6) =(ISZ2,ISZ2)
8 (IX8,IY8) =(−ISZ2,−ISZ2)
5 (IX5,IY5) =(−ISZ2,−ISZ2)

Figure 9. Pen position changes to draw an X for: a) a loop index of 1 (ISTRT) through 4; b) a loop index of 5 through 8 (IEND).

been defined for each symbol to set up the proper number of pen movements (one movement for each traverse of the loop). Note that the WRITE statement to the plotter (device 7) uses mode 5 for pen movement. This has the function of moving the pen by the change in coordinates defined, IX(I) and IY(I), with the pen down. The use of different modes is explained in the Appendix.

121: The computed GO TO statement transfers to statement 750 (card 144) for those "hollow" symbols (square, triangle, diamond) to put the pen back in its original position (including up or down position) when subroutine SYMBOL was called and then return to the calling program. The GO TO 750 for the hollow circle is a dummy instruction since the program skips to statement 800 before reaching this GO TO statement when KODE = 3. For the + and X symbols, the program skips to statement 800 where only the original up or down position of the pen is checked and reset before returning. The pen is at the starting point after drawing + or X. The other symbols require more drawing. For the symbol ✱, the + is drawn first and them X is superimposed on top of this. For this the program skips to statement 625 (card 126) to see if X has been superimposed. For the other solid figures (square, triangle, diamond), the program skips to statement 640 (card 129) or statement 645 (card 133) to decrement the size parameter for drawing smaller and smaller figures, thus, "filling in" the original figure. The GO TO 800 statement for the solid circle is a dummy instruction, since the program does not reach this statement when KODE = 9.

122-127: Here the subroutine checks to see if the symbol X has been superimposed over the + for drawing the symbol ✱. If + has just been drawn, the last vertical pen change, IY8, is 0 and the symbol X is still to be drawn. In this case the subroutine goes to statement 500 (card 112) to perform the superposition. If this has been done, IY8 = ISZ2, and the subroutine goes to statement 800 (card 146) to reset the pen to its original position when subroutine SYMBOL was called.

128-139: This section decrements the size parameters for the drawing of a solid square, a solid triangle, or a solid diamond, depending on the value of KODE. The new enclosing square has each dimension, ISZ, 1/100 inch shorter for the smaller diamond and 2/100 inch shorter for the smaller square or triangle. The pen first must move in within the previous symbol 1/100 inch to begin. Therefore, IX1 = -1. IY1 must also be redefined to bring the pen in for drawing the square or triangle. Therefore, in each of these two sections, IY1 = -IX1 = 1 or 1/100 inch. The length of half the enclosing square, ISZ2, is also reduced by 1/100 inch. The pen must move to the point where the drawing of the new smaller symbol is to start. Therefore, the drawing loop index is given a beginning value ISTRT = 1, rather than 2. The subroutine uses the computed GO TO statement to go to the appropriate section for defining pen movement coordinates according to KODE. Smaller and smaller symbols are drawn filling in the original until the pen is in the center of the symbol at the original point around which the symbol is being drawn. Then the subroutine skips to statement 800 (card 146) to reset the pen to an up or down position, as it was when subroutine SYMBOL was called.

140-148: If not already at the original location when SYMBOL was called (for the "hollow" square, triangle, circle, or diamond), the subroutine skips to statement 750 (card 144) to define the writing mode as mode 2. Next, using the write statement 775 (card 145), the pen is carried to the original point (LASTX, LASTY) with the pen up. If the pen is at the original point (for +, X, ✳, solid square, solid triangle, solid circle, or solid diamond), the subroutine comes directly to statement 800 (card 146) to check the original up or down position of the pen. IPEN = 0 if the pen was up, or IPEN = 100000 (octal) if the pen was down. If IPEN is negative, it is a "flag" that the pen has been placed back in the original "called position." If IPEN = 0, the subroutine goes to statement 725 (card 143) where the writing mode is set equal to 2 to raise the pen at the write statement 775 (card 145). IPEN is set equal to -1 to indicate that the pen is properly set and the subroutine returns to the calling program. If IPEN > 0 (*i.e.*, IPEN = 100000), the subroutine goes to statement 700 (card 140) where the writing mode is set equal to 3. This lowers the pen at write statement 775. IPEN is set equal to -1 to indicate that the pen has been properly set and the subroutine returns to the calling program. These writing modes are more fully explained in the appendix.

Function SLIM (MAXMIN, ALIMIT)

This function, SLIM (MAXMIN, ALIMIT), finds the maximum or minimum axis limit given the largest or smallest value to be plotted, ALIMIT. A minimum limit is found if $MAXMIN \leq 0$. In this case the value of ALIMIT is the smallest value to be plotted with respect to some axis. A maximum value is found if $MAXMIN > 0$. Then the value of ALIMIT is the greatest value to be plotted with respect to this axis.

Breakdown of Function SLIM--

016: Define the truncated integer LIMIT as the value which is to determine the maximum or minimum plotting limit:

$$LIMIT = ALIMIT$$

017: Define the difference of these two values as DIFF:

$$DIFF = ALIMIT-LIMIT$$

018-019: The value of MAXMIN indicates whether SLIM is called to find a maximum plotting limit or a minimum plotting limit. If $MAXMIN \leq 0$, this function goes to statement 1 (card 020) to return a minimum. If $MAXMIN > 0$, this function goes to statement 2 (card 021) to return a maximum.

020: The program reaches statement 1 when a minimum is desired. If DIFF is negative, the value of ALIMIT is a negative real number (*i.e.*, the common antilog of ALIMIT is a value < 1.0 but greater than zero), and the program goes to statement 3 (card 026). If DIFF is zero, this indicates that the value of ALIMIT is an integer (*i.e.*, the common antilog of ALIMIT is a value which is an integral power of 10) and the program goes to statement 4 (card 031). If DIFF is positive, this indicates that the value of ALIMIT is a positive real number (*i.e.*, the common antilog of ALIMIT is a value > 1.0, not an integral power of 10.) and the program goes to statement 4 (card 031).

021: The program reaches statement 2 when a maximum is desired. The various values of DIFF (negative real number, zero, or positive real number) have the same meaning for ALIMIT as in the description of card 020 above. However, the value of DIFF causes the program to proceed to different statements than above in order to find a maximum. The program goes to statement 5 (card 038) if DIFF is either a negative real number or zero. The program goes to statement 4 (card 031) if DIFF is a positive real number.

022-027: The program reaches statement 3 only when ALIMIT is a negative real number and SLIM is called to find a minimum limit (MAXMIN=0). In this case the returned limit value SLIM is:

$$\text{SLIM} = \text{LIMIT}-1 \qquad (254)$$

For example, suppose the program searches for the minimum diameter axis value where the smallest diameter is 0.3 micrometers:

$$\begin{aligned} &\text{SLIM(MAXMIN,ALIMIT)} && (255)\\ &= \text{SLIM}(0,\log_{10}(0.3)) && (256)\\ &= \text{SLIM}(0,-1.523) && (257) \end{aligned}$$

In this case LIMIT = -1 so that

$$\text{SLIM} = -1 -1 = -2 \qquad (258)$$

With SLIM returned as -2, the minimum limit for the diameter axis is 10^{-2} or 0.01. Therefore, even the smallest diameter value, 0.03, can be plotted on the resulting grid.

028-032: The program reaches statement 4 only when ALIMIT is a positive real number and the search is for a maximum grid limit (MAXMIN = 1). In this case the returned limit value, SLIM, is:

$$\text{SLIM} = \text{LIMIT} + 1 \qquad (259)$$

For example, suppose the program searches for the maximum cumulative mass loading axis limit when the largest value of the data is 8.6×10^4 milligrams per actual cubic meter:

$$\begin{aligned} & \text{SLIM(MAXMIN,ALIMIT)} && (260) \\ = \; & \text{SLIM}(1,\log_{10}(8.6 \times 10^4)) && (261) \\ = \; & \text{SLIM}(1,4.934) && (262) \end{aligned}$$

In this case, LIMIT = 4 so that

$$\text{SLIM} = \text{LIMIT} + 1 = 5.0 \qquad (263)$$

With SLIM returned as 5.0, the maximum limit for the cumulative mass loading axis is $1.0^{5.0}$. Therefore, even the largest cumulative mass loading value, 8.6×10^4, can be plotted on the resulting grid.

033-039: The three conditions for reaching statement 5 (card 038) and the resulting value of SLIM are discussed below. In each case SLIM = LIMIT.

1.) ALIMIT is a negative real number and the search is for a maximum grid limit (MAXMIN=1). Suppose the program is searching for the maximum cumulative mass loading axis limit when the largest value of the data is 0.8 milligrams per actual cubic meter:

$$\begin{aligned} & \text{SLIM(MAXMIN,ALIMIT)} && (264) \\ = \; & \text{SLIM}(1,\log_{10}(0.8)) && (265) \\ = \; & \text{SLIM}(1,-0.0969) && (266) \end{aligned}$$

In this case, LIMIT = 0 so that

$$\text{SLIM} = \text{LIMIT} = 0.0 \qquad (267)$$

With SLIM returned as 0.0, the maximum limit for the cumulative mass loading axis is $10^{0.0}=1$. Therefore, even the largest cumulative mass loading value, 0.8, can be plotted on the resulting grid.

2.) ALIMIT is an integer. The search may be for either a maximum (MAXMIN=1) or a minimum (MAXMIN=0). Suppose the program searches for the maximum axis limit for the dM/dlogD values is $1.0\text{x}10^6$ milligrams per dry normal cubic meter:

$$\text{SLIM(MAXMIN,ALIMIT)} \qquad (268)$$

$$= \text{SLIM}(1,\log_{10}(1.0\text{x}10^6)) \qquad (269)$$

$$= \text{SLIM}(1.6) \qquad (270)$$

In this case, LIMIT = 6 so that

$$\text{SLIM} = \text{LIMIT} = 6.0 \qquad (271)$$

With SLIM returned as 6.0, the maximum axis limit for the dM/dlogD values is $10^{6.0}$. The largest value of the dM/dlogD distribution, $1.0\text{x}10^6$, can be plotted on the resulting grid.

3.) ALIMIT is a positive real number and the search is for a minimum grid limit (MAXMIN=0). Suppose the program searches for the minimum diameter axis value where the smallest diameter is 1.2 micrometers:

$$\text{SLIM(MAXMIN,ALIMIT)} \qquad (272)$$

$$= \text{SLIM}(0,\log_{10}(1.2)) \qquad (273)$$

$$= \text{SLIM}(0.0.0792) \qquad (274)$$

In this case, LIMIT = 0 so that

$$\text{SLIM} = \text{LIMIT} = 0 \qquad (275)$$

With SLIM returned as 0.0, the minimum limit for the diameter axis is $10^{0.0}$ = 1.0. There, fore, the smallest diameter value, 1.2, can be plotted on the resulting grid.

040: Statement 6 returns the function value SLIM to the plotting subroutine which called it.

041: End.

Function XVAL(X1F,AMAX,AMIN,AS)

Function XVAL(X1F,AMAX,AMIN,AS) compares the value X1F to the given maximum and minimum grid values, AMAX and AMIN. If X1F is within the range of these two values, XVAL is set equal to X1F and returned. However, if X1F>AMAX, XVAL is returned as a value which would be plotted 0.15 inch outside the maximum grid limit, AMAX. Similarly, if X1F<AMIN, XVAL is returned as a value which would be plotted 0.15 inch outside the minimum grid limit, AMIN. Thus, the call to this function prevents disorientation of the plotter if trying to plot an extreme value beyond plotting limits.

Breakdown of Function XVAL--

09-011: X1F is checked here to see if it is greater than the maximum grid value, AMAX. If so, the routine goes to statement 86 (card 010) where the variable XVAL is set equal to a value beyond the maximum grid value, AMAX.

$$XVAL = AMAX + 0.15/AS \qquad (276)$$

where AS is the number of inches per grid unit. The function then returns this value of XVAL to the calling routine.

012-014: The routine comes to statement 87 (card 012) if the value of X1F is less than AMAX. X1F is checked here to see if it is less than the minimum grid value, AMIN. If so, the routine goes to statement 88 (card 013) where the variable XVAL is set equal to a value less than the minimum grid value, AMIN:

$$XVAL = AMIN - 0.15/AS \quad (277)$$

The function returns this value of XVAL to the calling subroutine.

015-017: The function routine goes to statement 89 (card 015) only if $AMIN \leq X1F \leq AMAX$, *i.e.*, only if the value of X1F is within the plotting limits. In this case, XVAL is returned equal to X1F. Thus, XVAL is set equal to X1F and returned.

Function YVAL(Y1F,BMAX,BMIN,BS)

This function is the same as XVAL(X1F,AMAX,AMIN,AS). See the description of this function above.

Subroutine CPPLOT(IDGEN,RHO,XMAX,XMIN,YMAX,YMIN,XS,YS)

This subroutine is called by subroutine CUMPCT or by mainline program STATIS to draw the grid for cumulative percent mass loading less than particle diameter vs. indicated particle diameter. It draws an ordinate probability scale axis labeling it "CUMULATIVE PERCENT" and an abscissa common log scale labeling it "PARTICLE DIAMETER (MICROMETERS)". The grid is labeled with the identification label, IDGEN, and density in grams per cubic centimeter, RHO. XMAX, XMIN, YMAX, and YMIN are the abscissa and ordinate axis limits while XS and YS are the abscissa and ordinate scale factors in inches per user's unit.

Breakdown of Subroutine CPPLOT--

011-018: Subroutine NDTRI(P,X,D,IE) is a subroutine from the IBM 360 Scientific Subroutine Package-Version III. It takes the first argument, P, in a fractional form and returns it in terms of the probability scale as the second argument, X. Here, NDTRI is used to find the maximum and minimum plotting limits for the vertical cumulative percent axis which is to use a probability scale. The maximum and minimum fractional limits used here for the first argument, P, are 0.9999 and 0.0001, respectively. The probability equivalent values returned as the second argument, X, are YMAX = +3.7191244 and YMIN = 3.7191244, respectively.

019-026: The lengths of the horizontal and vertical axes, XINCH and YINCH, are established here. XINCH = 4.5 inches and YINCH = 6.5 inches. These dimensions leave adequate room for legends and a caption on an 8-1/2 x 11-inch format.

027-033: The horizontal maximum and minimum plotting limits, XMAX and XMIN, are defined here in terms of the common log scale. The maximum particle diameter to be plotted is 100.0 micrometers. Thus, XMAX = $\log_{10}$ (100.0) = 2.0. The minimum particle diameter to be plotted is 0.1 micrometer. Thus, XMIN = $\log_{10}(0.1) = -1.0$.

034-038: The horizontal and vertical scale factors, XS and YS, are established here in inches/user's unit:

$$\mathrm{XS} = \mathrm{XINCH}/(\mathrm{XMAX}-\mathrm{XMIN}) \tag{278}$$

$$\mathrm{YS} = \mathrm{YINCH}/(\mathrm{YMAX}-\mathrm{YMIN}) \tag{279}$$

039-042: When subroutine CPPLOT begins execution, the plotter pen should be in its "home position", that is, on the base line of the plotter paper. This position must be defined in terms of the user's origin and stored as a reference point for the plotter. The user's origin is (XMIN, YMIN) and has values as defined above at card 018 and card 033. The pen's "home position" is (XMIN,Y0). The horizontal coordinate is the same as for the user's origin. The vertical coordinate is defined so that the user's origin is placed two inches above the "home position":

$$Y0 = YMIN - 2.0/YS \qquad (280)$$

043-047: Subroutine SCALF(XS,YS,XMIN,Y0) stores the X and Y axis scale factors, XS and YS, and also the original pen position at the call of subroutine CPPLOT, (XMIN, Y0), for use by the plotter.

048-061: This section draws the Y-axis on the left side of the graph. The call to subroutine FPLOT (0, XMIN, YMAX) moves the pen to the left side of the plot without up or down pen movement. (The pen is in the up position at this call to FPLOT.) Code variables IMIN = 1 and IMAX = 25 are defined here for use by subroutine YPROB. IMIN is the code value which determines the minimum cumulative fraction limit for the graph. IMIN = 1 causes this minimum limit to be 0.0001. IMAX is the code which determines the maximum fraction limit for the graph. IMAX = 25 causes this maximum limit to be 0.9999. The call to subroutine YPROB(XS, YS, XMIN, 0, IMIN, IMAX) causes the Y-axis to be drawn beginning with the maximum cumulative percent to be plotted, 99.99%. Tick marks are drawn downward along the vertical axis to the minimum cumulative percent to be plotted, 0.01%. XS and YS are the horizontal and vertical scale factors previously defined. XMIN is the horizontal position of the Y-axis. The fourth argument, KODE = 0, indicates that the axis is to be labeled to the left of the axis.

062-071: This section labels the left Y-axis as cumulative percent. The character width and height, XCS and YCS, are each defined as 0.15 inch. The initial horizontal pen position (at base of first character) is one inch to the left of XMIN, that is, one inch to the left of the Y-axis:

$$X = XMIN - 1.0/XS \qquad (281)$$

The initial vertical pen position os defined so that the label is centered along the Y-axis:

$$Y = YMIN + (YMAX-YMIN)/2. - 9.(YCS/YS) \qquad (282)$$

The angle of writing is PI/2. where PI = 3.1415. The plotter is prepared for writing the label by the call to FCHAR(X,Y,SCS,YCS,PI/2.), and the write command prints "CUMULATIVE PERCENT" along the left vertical axis.

072-077: This section draws the X-axis. This axis is drawn as a common log scale. The number of common log cycles to be drawn, IXRAN, is defined as the difference in the maximum and minimum X-axis limits:

$$IXRAN = XMAX - XMIN \qquad (283)$$

The call to plotter subroutine XSLBL(XS, YS, XMIN, YMIN, IXRAN, XMIN) labels the X-axis for the common log scale. The call to plotter subroutine XLOG(XS, YS, XMAX, YMIN, -1, IXRAN) draws the X-axis scale. It is drawn from (XMAX,YMIN) to the left since the fifth argument is -1.

078-084: This section labels the X-axis as "PARTICLE DIAMETER (MICROMETERS)". The initial horizontal pen position, X, for describing the horizontal axis is defined so that the writing is centered along the horizontal axis:

$$X = XMIN + (XMAX-XMIN)/2. - 16.(XCS/XS) \quad (284)$$

The initial vertical pen position, Y, is located far enough below the X-axis (0.7 inch) that the height of written characters does not interfere with the drawn axis:

$$Y = YMIN - 0.7/YS \quad (285)$$

The call to plotter subroutine FCHAR(X,Y,XCS,YCS, 0.) gives the initial pen coordinates (X,Y) and the character width and height, XCS and YCS, and the angle for writing in radians, 0.0. This prepares the plotter for the next to command which is to write "PARTICLE DIAMETER (MICROMETERS)" along the horizontal axis.

085-099: This section writes the general identification label IDGEN above the plotting grid. IDGEN is written with an initial pen position (X,Y) so that X = XMIN, in line with the vertical axis, and Y = YMAX + 0.5/YS, 0.5 inch above the plot. The width and height of these characters in inches are:

$$XCS = 0.056 \quad (286)$$

$$YCS = 0.100 \quad (287)$$

The DO-loop at cards 093-097 finds the last character of the IDGEN array and labels it as $IDGEN_J$. This prevents undue pen movement in writing the identification label.

100-104: This section writes the density, RHO, above the plotting grid beneath IDGEN. The initial pen position (X,Y) for writing the density is, again, in line with the vertical axis and 0.25 inch above the graph:

$$X = XMIN \quad (288)$$

$$Y = YMAX + 0.25/YS \quad (289)$$

Character width, height, and angle of writing are the same as for writing IDGEN.

104: Subroutine CPPLOT returns to the calling program; either subroutine CUMPCT or mainline program STATIS.

Subroutine YPROB(XS,YS,X,KODE,IMIN,IMAX)

This subroutine, YPROB(XS,YS,X,KODE,IMIN,IMAX),draws the log probability ordinate used in graphing cumulative percent concentration and penetration-efficiency.

Before calling YPROB, the calling arguments must be defined. XS and YS are the horizontal and vertical scale factors in inches per unit. X is the position on the X-axis at which the Y-axis is to be located. KODE determines whether labeling of the axis is to the left (KODE = 0) or to the right (KODE = 1) of the Y-axis. For example, when drawing the grid for cumulative percent concentration or percent efficiency, this Y-axis is drawn on the left side of the graph. KODE is set equal to zero to write percentages to the left of the tick marks, beginning at the top with 99.99% and descending to the desired minimum value. When drawing the grid for percent penetration, this Y-axis is drawn on the right of the graph. KODE is set equal to one to write percentages to the right of the tick marks. The percentages begin with 0.01% at the top and ascend in value downward to the desired maximum. IMIN and IMAX are code values for the minimum and maximum cumulative percent or percent efficiency to be shown on the plot. The fractional value corresponding to each value of IMIN or IMAX is given in Table 15 along with fractional big tick mark values, number of small tick marks between this and the next large tick mark, and the fractional increment between each of these small tick marks. The position of each tick mark on the grid, and the vertical position of each plotted fraction, is

TABLE 15 GUIDE TO YPROB SUBROUTINE

	Big tick values (BTV)	Small tick increments (STI)	Number of small ticks (NST)	IMIN (or) IMAX	Fractional efficiency number
YMIN	0.0001	0.0001	3	1	0.01
	0.0005	0.0001	4	2	0.05
	0.001	0.0005	1	3	0.1
	0.002	0.001	2	4	0.2
	0.005	0.001	4	5	0.5
	0.01	0.002	4	6	1.0
	0.02	0.01	2	7	2.0
	0.05	0.01	4	8	5.0
	0.1	0.01	9	9	10.0
	0.2	0.02	4	10	20.0
	0.3	0.02	4	11	30.0
	0.4	0.02	4	12	40.0
	0.5	0.02	4	13	50.0
	0.6	0.02	4	14	60.0
	0.7	0.02	4	15	70.0
	0.80	0.01	4	16	80.0
	0.9	0.01	4	17	90.0
	0.95	0.01	2	18	95.0
	0.98	0.002	4	19	98.0
	0.97	0.001	4	20	99.0
	0.995	0.001	2	21	99.5
	0.998	0.0005	1	22	99.8
	0.999	0.0001	4	23	99.9
	0.9995	0.0001	3	24	99.95
YMAX	0.9999	0.0	0	25	99.99

determined by taking the inverse of the normally distributed probability function. This is done in the subroutine NDTRI from the IBM 360 Scientific Subroutine Package - Version III.

Subroutine YPROB was written at Southern Research Institute. However, its only function, like YLOG, LGLBL, XLOG, and XLBL, is to draw an axis according to a functional form, and is, therefore, not discussed here in a line by line breakdown.

SECTION 4

USER INSTRUCTIONS

This section is a user's guide for each of the mainline programs and should provide enough information for the user to execute the mainline programs easily. Refer to Section 3 if any programming changes are to be made. For each mainline program, requirements for program execution are given (*e.g.*, maximum number of runs for one execution, cards which may be omitted under certain circumstances, etc.). Also, a table of card formats is included for each of the mainline programs. It should be noted that the job streams listed are for the PDP 15/76 computer system. They are presented here to show the file names and numbers which must be assigned and also to show the ordering of data cards. Necessary changes in the Job Control Language (JCL) must be made for other computer systems. File reference information, and a table listing which subprograms and functions are called by mainline programs and other subroutines are included at the end of this section.

MAINLINE PROGRAM MPPROG

Requirements for Program Execution

The following is a list of implied user instructions for execution of mainline program MPPROG:

1. Only one type of impactor data (*e.g.*, Andersen, Brink, etc.) can be run under one MPPROG XCT.
2. A maximum number of impactor data sets is 50 under one MPPROG XCT.

3. Cards 1-2 apply to one test (a test being made up of runs where one type of impactor is used). These cards may not be repeated.
4. Cards 3-8 make up one impactor run. These cards may be repeated.
5. Card 3 stops the program if MPACNO = 0 (i.e., 0 punched in column 1 of card 3).
6. The user should make the appropriate changes in subroutine CUT and the COMMON BLOCK routine for Common Block 2 in order to load calibration constants (values of $\sqrt{\psi}$) and hole diameter sizes for the impactors used. The calibration values listed in program MPPROG are those used by Southern Research Institute and are here for purposes of illustration only.

Card Format

Table 16 gives the variables to be punched on each card for MPPROG,columns in which to punch them and format used. A description of the variables, and any options available are also given.

Sample Job Stream

The following is a listing of a sample job stream for 10 impactor runs as would be required for the PDP 15/76 computer system:

```
$JOB ENAME
$D DP1 <KMC> KMC001
$ASG 12:DP1(KMC)
$XCT MPPROG:DP1(KMC)
CARD 1
CARD 2
CARDS 3-8
CARDS 3-8
```

TABLE 16. MPPROG INPUT CARD FORMAT

Card no.	Card column	Format	Variable name	Description/options/units
1	2	I2	MPACTY	Impactor type, 1 = Andersen, 2 = Brink, 3 = University of Washington (Pilat), 4 = MRI
	4	I2	MAERO	D_{50} values are calculated twice. If the physical density is used first, i.e., the value of RHO punched on card 4 is > 1.0, then a choice is available as to which definition of aerodynamic diameter (unit density) is used in the second pass through MPPROG. If MAERO = 0, the "classic" definition of aerodynamic diameter defined by the Task Group on Lung Dynamics (TGLD) is used. If MAERO = 1, the aerodynamic impaction diameter as defined by Mercer or Calvert is used. If no physical density results are desired, then RHO is entered as 1.0 and results for both unit density definitions of particle diameter are presented. The TGLD definition is given first. In this case the value of MAERO punched on this card is overridden. See the description of RHO on card 4.
2	1-80	80A1	IDALL	Run identification. This should include test site, dates, conditions, etc. Applies to all runs in the set.
3	2	I2	MPACNO	Impactor number - MPACNO = 0 stop program MPACNO > 0 run program

MPACNO	1	2	3	4	5	6
Brink	A	B	C	D		
U. of W. Pilat	A	B	C	D		
ANDY(plate set)	1	2	3	8	7	6
MRI	A					

Card no.	Card column	Format	Variable name	Description/options/units
4	1-5	F5.2	PO	Gas pressure at inlet, inches of Hg.
	6-11	F6.1	TFS	Temperature of stack, °F
	12-17	F6.1	TFI	Temperature of impactor, °F
	18-21	F4.2	RHO	Assumed density for the first calculation of D_{50}'s. If RHO is entered as the physical density (i.e., RHO>1.0), then the second calculation of D_{50}'s is based on an assumed unit density where the definition of aerodynamic diameter is determined by MAERO on card 2 above. If RHO is entered as unity (i.e., RHO=1.0), then the first calculations of D_{50}'s are made using the classic definition of aerodynamic diameter (Task Group on Lung Dynamics) and the second calculations of D_{50}'s are made using the aerodynamic impaction diameter (Mercer-Calvert).
	22-26	F5.1	DUR	Duration of sampling, minutes
	27-31	F5.1	DMAX	Maximum particle diameter collected, micrometers
	32	I1	MC3	MC3 = 1, if Brink with cyclone; 0 if no cyclone used
	33	I1	M00	M00 = 1, if Brink with stage 0; 0 if no stage 0 used
	34	I1	MS	Last stage, MS = 5 or 6, if Brink; 0 if Brink not used
	35	I1	MF	MF = 1 to compute SPLIN1 fit with backup filter catch included in fit; 0 if not included in fit
5	1-06	F6.4	FG(1)	Dry gas fraction of carbon dioxide
	7-12	F6.4	FG(2)	Dry gas fraction of carbon monoxide
	13-18	F6.4	FG(3)	Dry gas fraction of nitrogen
	19-24	F6.4	FG(4)	Dry gas fraction of oxygen
	25-30	F6.4	FG(5)	Fraction of water-steam
6				Mass captured on impactor stages in milligrams

Card no.	Card column	Format	Variable name	ANDERSEN	BRINK	U. of W.	MRI
				Backup filter			
	1-6	F6.2	MASS(1)	Stage 8	Stage 6	Stage 7	Stage 7
	7-12	F6.2	MASS(2)	Stage 7	Stage 5	Stage 6	Stage 6
	13-18	F6.2	MASS(3)	Stage 6	Stage 4	Stage 5	Stage 5
	19-24	F6.2	MASS(4)	Stage 5	Stage 3	Stage 4	Stage 4
	25-30	F6.2	MASS(5)	Stage 4	Stage 2	Stage 3	Stage 3
	31-36	F6.2	MASS(6)	Stage 3	Stage 1	Stage 2	Stage 2
	37-42	F6.2	MASS(7)	Stage 2	Stage 0	Stage 1	Stage 1
	43-48	F6.2	MASS(8)	Stage 1	Cyclone		
	49-54	F6.2	MASS(9)				

Card no.	Card column	Format	Variable name	Description/options/units
7	1-7	F7.4	F	Impactor flow rate in ACFM
8	1-65	80A1	ID	Run number, date, time, port/points, type of test, location of test site

```
CARDS 3-8
CARDS 3-8
CARDS 3-8
CARDS 3-8
CARDS 3-8
CARDS 3-8
CARDS 3-8
CARDS 3-8
CARD 3   (Last card blank or nonpositive integer.)
$END
$SPOOLER END-OF-DECK CARD
```

MAINLINE PROGRAM SPLIN1

Requirements for Program Execution

The following is a list of user instructions for the execution of mainline program SPLIN1:

1. Mainline program MPPROG must be executed prior to execution of mainline program SPLIN1 since all data used by SPLIN1 are stored on file by MPPROG.
2. Unless otherwise specified on card 1, curve fits are made for all data sets (for both Stokes diameter and aerodynamic diameter where physical density was input to MPPROG or for both definitions of aerodynamic diameter where unit density was input to MPPROG).
3. Card 2 is omitted if all data sets are to be curve fit. Card 2 is repeated for each set of data to be curve fit and left blank to end program.

Card Format

Table 17 gives the variables to be punched on each card for SPLIN1, columns in which to punch them and format used, a description of the variables, and any options.

TABLE 17. SPLIN1 INPUT CARD FORMAT

Card no.	Card column	Format	Variable name	Description/options/units
1	1-2	I2	KREAD	KREAD = 0, make fit to all sets of cumulative mass loading vs. D_{50} of values on file; KREAD = 1, read in sets to be fitted by record number.
2	1-2	I2	IAV	Record number of run to be fitted if physical density was input to MPPROG, IAV = 1, 3, 5, ..., 2N + 1 for runs with Stokes diameter; IAV = 2, 4, 6, ..., 2N - 1 for runs with aerodynamic diameter (definition of aerodynamic diameter user specified in MPPROG). If unit density was input to MPPROG, odd records contain data for Mercer's[2] aerodynamic diameter; even records contain data for aerodynamic diameter as defined by Task Group on Lung Dynamics.[1] IAV = 0 to show end of the card deck after last record. This card is omitted if KREAD on card 1 is 0 or left blank.

Sample Job Streams

It should be noted that comments regarding the sample job streams listed here refer to the case in which the physical particle density is input to program MPPROG.

The following is a listing of a sample job stream for 10 impactor runs as would be required by the PDP 15/76 computer system. This job stream would make cumulative mass loading vs. D_{50} curve fits to runs 1, 4, 5, 7, and 8 assuming physical density (Stokes diameter) and runs 2, 3, 4, 6, 9, and 10 assuming unit density (aerodynamic diameter):

```
$JOB ENAME
$D DP1 <KMC> FILSPL
$ASG 12:DP1(KMC)
$ASG 13:DP1(KMC)
$XCT SPLIN1:DP1(KMC)
CARD 1 (Reads integer >0 in columns 1-2)
CARD 2 (Reads 01)
CARD 2 (Reads 07)
CARD 2 (Reads 09)
CARD 2 (Reads 13)
CARD 2 (Reads 15)
CARD 2 (Reads 04)
CARD 2 (Reads 06)
CARD 2 (Reads 08)
CARD 2 (Reads 12)
CARD 2 (Reads 18)
CARD 2 (Reads 20)
$END
$SPOOLER END-OF-DECK CARD
```

The following is a listing of a sample job stream for 10 impactor runs, and yields cumulative mass loading vs. D_{50} curve fits to all runs for both physical and aerodynamic diameter:

```
$JOB ENAME
$D DP1 <KMC> FILSPL
$ASG 12:DP1(KMC)
$ASG 13:DP1(KMC)
```

```
$XCT SPLIN1:DP1(KMC)
CARD 1 (Reads blank or nonpositive integer in columns 1-2)
$END
$SPOOLER END-OF-DECK CARD
```

MAINLINE PROGRAM GRAPH

Requirements for Program Execution

The following is a list of user instructions for execution of the mainline program GRAPH:

1. Mainline program MPPROG must be executed prior to execution of mainline program GRAPH. If any plots derived from and including cumulative mass loading fits are called for, mainline program SPLIN1 must also be executed before GRAPH.
2. Card 1 applies to one test and may not be repeated.
3. Cards 2-3 are not repeated if the types of graphs desired are the same for every run.
4. Cards 2-3 apply to one impactor run and are repeated if the types of graphs desired are different for different impactor runs. In this case the variable IREPET is set equal to 1. Refer to Table 18 for more specific information.
5. Up to 10 sets of raw data can be plotted on one graph. Only one set of fitted data can be plotted on one graph.

Card Format

Table 18 gives the variables to be punched on each card, columns in which to punch them, the format used, a description of the variables, and any options. Descriptions/options/units are discussed under the assumption that physical density is input to program MPPROG. The results based on physical density and unit density (definition of aerodynamic diameter user specified) are stored in alternating records of the output file from MPPROG.

TABLE 18. GRAPH INPUT CARD FORMAT

Card no.	Card column	Format	Variable name	Description/options/units
1	1	I1	ISIZ1	ISIZ1 = 0 for cumulative mass loading and cumulative % graphs to have standard grids; ISIZ1 = 1 for data regulated grids
	2	I1	ISIZ2	ISIZ2 = 0 for mass size concentration to have standard grids; ISIZ2 = 1 for data regulated grids
	3	I1	ISIZ3	ISIZ3 = 0 for number size concentration to have standard grids; ISIZ3 = 1 for data regulated grids
	4	I1	IREPET	IREPET = 0 for plot variables to be the same for all runs. If this is the case, then only one set of plotting control variables is read into the program. IREPET = 1 for plot variables to be different for each run. In this case, as many card sets as there are impactor runs are read in.
2	1	I1	MPLOT	MPLOT = 1 to make new grid for all of the raw data graphs of cumulative mass loading, mass size concentration, and number size concentration. This applies to both aerodynamic and Stokes diameter graphs. For the first data set this value must be greater than zero. If MPLOT = 0 for each data set after the first, more than one run of the same type will be plotted on the same graph. (That is, if six runs of cumulative mass loadings are desired on the same grid, use MPLOT = 1 for the first data set and MPLOT = 0 for the remaining 5 data sets.) This variable only applies to the raw data point graphs.
	2	I1	J1	J1 = 0, make a cumulative mass loading plot for unit density; J1 = 1, suppress plot
	3	I1	J2	J2 = 0, make a mass size distribution plot for unit density; J2 = 1, suppress plot
	4	I1	J3	J3 = 0, make a number size distribution plot for unit density; J3 = 1, suppress plot
	5	I1	J4	J4 = 0, make a cumulative mass loading plot for physical density; J4 = 1, suppress plot
	6	I1	J5	J5 = 0, make a mass size distribution plot for physical density; J5 = 1, suppress plot
	7	I1	J6	J6 = 0, make a number size distribution plot for physical density; J6 = 1, suppress plot
3	1	I1	JP1	JP1 = 0, make fitted cumulative mass loading graph for unit density superimposed on plot of raw data; JP1 = 1, suppress plot
	2	I1	JPCNT1	JPCNT1 = 0, make fitted cumulative % mass loading distribution for unit density; JPCNT1 = 1, suppress plot plot
	3	I1	JP2	JP2 = 0, make fitted mass size distribution for unit density superimposed on plot of raw data; JP2 = 1, suppress plot
	4	I1	JP3	JP3 = 0, make fitted number size distribution for unit density superimposed on plot of raw data; JP3 = 1, suppress plot
	5	I1	JP4	JP4 = 0, make cumulative mass loading for physical density superimposed on plot of raw data; JP4 = 1, suppress plot
	6	I1	JPCNT4	JPCNT4 = 0, make cumulative % mass loading for physical density; JPCNT4 = 1, suppress plot
	7	I1	JP5	JP5 = 0, make mass size distribution for physical density superimposed on plot of raw data; JP5 = 1, suppress plot
	8	I1	JP6	JP6 = 0, make number size distribution for physical density superimposed on plot of raw data; JP6 = 1, suppress plot

Sample Job Streams

The following is a sample job stream for impactor runs where different graphs are desired for particular impactor runs:

```
$JOB ENAME
$ASG 12:DP1(KMC)
$ASG 10:DP1(KMC)
$ASG 13:DP1(KMC)
$XCT GRAPH:DP1(KMC)
CARD 1
CARDS 2-3
CARDS 2-3
CARDS 2-3
CARDS 2-3
CARDS 2-3
CARDS 2-3
CARDS 2-3
CARDS 2-3
CARDS 2-3
CARDS 2-3
$END
$SPOOLER END-OF-DECK CARD
```

The following listing is a sample job stream for 10 impactor runs, but this job stream yields the same graphs for all runs as instructed by coding on cards 2-3:

```
$JOB ENAME
$ASG 12:DP1(KMC)
$ASG 10:DP1(KMC)
$ASG 13:DP1(KMC)
$XCT GRAPH:DP1(KMC)
CARD 1
CARDS 2-3
$END
$SPOOLER END-OF-DECK CARD
```

The user may instead desire to input only unit density to MPPROG yielding calculations based on the two different definitions of aerodynamic diameter (Mercer's[2] and Task Group on Lung Dynamics[1]).

MAINLINE PROGRAM STATIS

Requirements for Program Execution

The following is a list of user instructions for execution of mainline program STATIS:

1. Mainline programs MPPROG and SPLIN1 must be executed prior to the execution of STATIS.
2. No statistical information can be calculated unless SPLIN1 has processed the cumulative mass versus particle diameter data and made curve fits.
3. Card 1 applies to a test where all runs (either inlet or outlet) are to be statistically combined. Card 1 is not repeated.
4. Input data cards 2-3 apply to calculations for a physical density. Cards 4-5 apply to unit density calculations. All four cards are included if statistical analysis for both densities is desired. When statistical results are desired for one density and not the other, one card is deleted. For example, if statistical analysis of only physical density data are desired, card 5 is omitted since this card specifies the maximum plotting diameter for statistical results where a unit density is assumed.
5. This program processes control device inlet or outlet information separately. Care must be taken not to delete an "inlet DM/DLOGD file" when executing STATIS on control device outlet results.

Card Format

Table 19 gives the variables to be punched on each card, columns in which to punch them, the format used, a description of the variable, and any options available to the user.

TABLE 19. STATIS INPUT CARD FORMAT

Card no.	Card column	Format	Variable name	Description/option/units
1	1	I1	INOUT	INOUT = 1 for inlet data; INOUT = 2 for outlet data
2	1	I1	N	N = 1 for physical density data
	2	I1	NOFILE	NOFILE = 1, calculations are not to be made for this density and remainder of variable values on this card are ignored; NOFILE = 0, calculations are to be made for physical density
	3	I1	IPLT1	IPLT1 = 0, plot statistical graph of cumulative mass loading; IPLT1 = 1, suppress plot
	4	I1	IPLT2	IPLT2 = 0, plot statistical graph of mass size distribution; IPLT2 = 1, suppress plot
	5	I1	IPLT3	IPLT3 = 0, plot statistical graph of number size distribution; IPLT3 = 1, suppress plot
	6	I1	IPLT4	IPLT4 = 0, plot statistical graph of cumulative % mass loadings; IPLT4 = 1, suppress plot
	7	I1	ISIZ1	ISIZ1 = 0 for cumulative mass loading to have standard grids; ISIZ1 = 1 for data regulated grids
	8	I1	ISIZ2	ISIZ2 = 0 for mass size distribution to have standard grids; ISIZ2 = 1 for data regulated grids
	9	I1	ISIZ3	ISIZ3 = 0 for number size distribution to have standard grids; ISIZ3 = 1 for data regulated grids
	10	I1	NCUCON	NCUCON = 0, calculate a constant of integration for particles with diameters smaller than 0.25 micron to find average cumulative mass loading; NCUCON = 1, do not calculate a constant of integration for particles with diameters smaller than 0.25 micron to find average cumulative mass loading
3	1-5	F5.1	PEND	Largest diameter size for calculations for assumed physical density; all statistical plotting stops at this diameter unless PEND = 0. Then the physical density plots and calculations stop at 8.0 micrometers. This card is omitted if NOFILE = 1 on card 2.
4	1	I1	N	N = 2 for unit density data
	2	I1	NOFILE	As on card 2, applied to unit density
	3	I1	IPLT1	As on card 2, applied to unit density
	4	I1	IPLT2	As on card 2, applied to unit density
	5	I1	IPLT3	As on card 2, applied to unit density
	6	I1	IPLT4	As on card 2, applied to unit density
	7	I1	ISIZ1	As on card 2, applied to unit density
	8	I1	ISIZ2	As on card 2, applied to unit density
	9	I1	ISIZ3	As on card 2, applied to unit density
	10	I1	NCUCON	As on card 2, applied to unit density
5	1-5	F5.1	PEND	Largest diameter size for calculations for assumed unit density; all statistical plotting stops at this diameter unless PEND = 0. Then the unit density plots and calculations stop at 8.0 micrometers. This card is omitted if NOFILE = 1 on card 4.

Descriptions/options/units are discussed under the assumption that physical density is input to program MPPROG. The results based on physical density and unit density (a definition of aerodynamic diameter user specified) are stored in alternating records of the output file from MPPROG. The user may instead desire to input only unit density to MPPROG yielding calculations based on the two different definitions of aerodynamic diameter (Mercer's[2] and Task Group on Lung Dynamics[1]).

Sample Job Streams

The following is a sample job stream for statistical analysis of assumed Stokes diameter data (inlet or outlet) assuming physical density input to MPPROG:

```
$JOB ENAME
$D DP1 <KMC> JWJ001 (for inlet analysis)
  or
$D DP1 <KMC> JWJ002 (for outlet analysis)
$ASG 12:DP1(KMC)
$ASG 13:DP1(KMC)
$ASG 20:DP1(KMC) (for inlet analysis)
  or
$ASG 21:DP1(KMC) (for outlet analysis)
$XCT STATIS:DP1(KMC)
CARD 1
CARDS 2-3 (N = 1 and NOFILE = 0 on card 2)
CARD 4    (N = 2 and NOFILE = 1)
$END
$SPOOLER END-OF-DECK CARD
```

The following is also a sample job stream for statistical analysis of data. This job stream yields statistical analysis for both Stokes diameter data and aerodynamic diameter data assuming physical density input to MPPROG:

```
$JOB ENAME
$D DP1 <KMC> JWJ001 (for inlet analysis)
  or
$D DP1 <KMC> JWJ002 (for outlet analysis)
$ASG 12:DP1(KMC)
$ASG 13:DP1(KMC)
```

```
$ASG 20:DP1(KMC) (for inlet analysis)
  or
$ASG 21:DP1(KMC) (for outlet analysis)
$XCT STATIS:DP1(KMC)
CARD 1
CARDS 2-5
$END
```

MAINLINE PROGRAM PENTRA

Requirements for Program Execution

The following is a list of user instructions for execution of mainline program PENTRA:

1. Mainline programs MPPROG, SPLIN1, and STATIS must be executed in this order twice before PENTRA can be executed: once for inlet and once for outlet statistical analysis.
2. Card 1 is a general identification label for the test (site, date, etc.) and is not repeated.
3. Card 2 indicates whether the operator wishes to use the internally defined minimum limit of the fractional efficiency graph (0.800 or 80%). If so, card 2 is left blank and cards 3-4 are omitted. Cards 3-4 are included if ICHRAN does not = 0. Card 3 then gives coding for this minimum limit, IMIN; card 4 specifies this limit as a fraction, YMINFR. See Table 20 for values of IMIN and the corresponding minimum fractional efficiency.

Card Format

Table 21 gives the variables to be punched on each card, columns in which to punch them, the format used, a description of the variable, and any options available to the user.

TABLE 20. MINIMUM FRACTIONAL EFFICIENCY CORRESPONDING TO A CHOSEN VALUE OF IMIN

IMIN	Minimum fractional efficiency, YMINFR
1	0.01
2	0.05
3	0.1
4	0.2
5	0.5
6	1.0
7	2.0
8	5.0
9	10.0
10	20.0
11	30.0
12	40.0
13	50.0
14	60.0
15	70.0
16	80.0
17	90.0
18	95.0
19	98.0
20	99.0
21	99.5
22	99.8
23	99.9
24	99.95
25	99.99

TABLE 21. PENTRA INPUT CARD FORMAT

Card no.	Card column	Format	Variable name	Description/options/units
1	80	80A1	IDGEN	General identification label that is output to line-printer, and written at the top of the efficiency graph
2	1	I1	ICHRAN	ICHRAN = 0, determines the standard output for the efficiency plot, which is 99.99-80 percent efficiency and 20-0.01 percent penetration for the probability axis. The log-log axis standard output is 100-0.01 percent penetration and 99.99-0.0 percent efficiency. ICHRAN = 1 gives the option of changing the axis on the y scale of the efficiency plots by card input.
	2	I1	NSPCON	NSPCON = 0, plot confidence limit if possible; NSPCON = 1 suppresses confidence limits.
3	1-2	I2	IMIN	Coding to correspond to minimum value on y axis. See Table 19 for IMIN coding corresponding to YMINFR values. This card is omitted if ICHRAN = 0 on card 2.
4	1-5	F5.4	YMINFR	Minimum fractional efficiency on plot. This card is omitted if ICHRAN = 0 on card 2.

Sample Job Streams

The following is a listing of a sample job stream for penetration-efficiency analysis which yields the minimum graph limit, 80% efficiency, defined in PENTRA:

```
$JOB ENAME
$ASG 20:DP1(KMC)
$ASB 21:DP1(KMC)
$XCT PENTRA:DP1(KMC)
CARD 1
CARD 2 (blank or 0's in columns 1-2)
$END
$SPOOLER END-OF-DECK CARD
```

The following is also a listing of a sample job stream for penetration-efficiency analysis. This job stream yields a minimum graph limit of 95% efficiency:

```
$JOB ENAME
$ASG 20:DP1(KMC)
$ASG 21:DP1(KMC)
$XCT PENTRA:DP1(KMC)
CARD 1
CARD 2 (nonzero integer in column 1-2)
CARD 3 (18 in columns 1-2)
CARD 4 (.9500 in columns 1-5)
$END
$SPOOLER END-OF-DECK CARD
```

FILE REFERENCE INFORMATION

Table 22 shows pertinent information about the files used in all of the main programs which comprise the cascade impactor data reduction system. File names, decimal and octal record numbers, record numbers, type, and program use are included in this table.

TABLE 22. FILE REFERENCE INFORMATION

File name	File no. (decimal)	File no. (octal)	Record length (words)	Number of records	Random or sequential	Used in programs	Input or output to program
FILNAM = KMC001 BIN	10	12	251	101	R	MPPROG	O
						SPLIN1	I
						GRAPH	I
						STATIS	I
FILSPL = FILSPL BIN	11	13	507	100	R	SPLIN1	O
						GRAPH	I
						STATIS	I
FGRAPH = GRAPH0 BIN	8	10	15	50	R	GRAPH	O
FILNM1 = JWJ001 BIN	16	20			S	STATIS	O
						PENTRA	I
						PENLOG	I
FILNM2 = JWJ002 BIN	17	21			S	STATIS	O
						PENTRA	I
						PENLOG	I

PROGRAM AND SUBPROGRAM CALLING LIST

Table 23 lists the subroutines and function subprograms called by mainline programs and other subroutines in the cascade impactor data reduction system. This list should aid the user when mainline programs or major subprograms are run separately.

TABLE 23. SUBROUTINES AND FUNCTION SUBPROGRAMS CALLED BY MAINLINE AND OTHER SUBROUTINES

CALLING PROGRAMS	CALLED SUBPROGRAMS AND FUNCTIONS																																	
	AVCON	COMBK1	COMBK2	CPPLOT	CUM	CUMPCT	CUT	DMDNGD	FCHAR	FPLOT	JOE1	JOE2	LABEL	LGLBL	MEAN	NDTRI	PIONT	SCALF	SIMQ	SLIM	STAGE	STATPT	STPLOT	SYMBOL	VIS	WALLY1	WALLY2	WALLY3	XLOG	XSLBL	XVAL	YLOG	YPROB	YVAL
Mainline programs																																		
MPPROG		●	●		●		●	●							●						●				●									
GRAPH						●																				●	●	●						
PENLOG									●	●				●				●						●					●	●	●	●		●
PENTRA									●	●						●		●						●					●	●	●		●	●
SPLIN1																			●															
STATIS	●			●						●												●	●											
Subroutines																																		
CUMPCT				●						●						●															●			●
CPPLOT									●	●						●		●											●	●			●	
JOE1										●																					●			●
JOE2										●																					●			●
LABEL									●																									
LGLBL									●																									
PIONT																								●										
STATPT										●						●								●							●			●
STPLOT									●					●				●		●									●	●		●		
WALLY1									●	●	●		●	●			●	●		●									●	●	●	●		●
WALLY2									●	●		●	●	●			●	●		●									●	●	●	●		●
WALLY3									●	●		●	●	●			●	●		●									●	●	●	●		●
XLOG										●																								
XSLBL									●																									
YLOG										●																								
YPROB									●	●						●																		

SECTION 5

EXAMPLE CALCULATIONS

In this section we present the results of example calculations which may be used to check the proper functioning of the programs. This section is divided into two parts. The first part results from a series of executions of MPPROG for every allowed configuration of an Andersen, Brink, University of Washington (U of W), and Meteorology Research Incorporated (MRI) impactor. There are other possible configurations for the Brink and MRI impactors, but we have selected those which are most commonly used. Other configurations can be used with program modification. The data decks are given first, then the printouts for physical and unit density follow. Results for all three particle diameter definitions are presented for each configuration of each impactor: Stokes, Task Group on Lung Dynamics (TGLD), and Mercer. Note that all data decks are set up with NAERO=0 so that results with Stokes diameters for physical density and TGLD aerodynamic diameters for unit density will be printed. For aerodynamic diameters based on Mercer's definition, NAERO must be set to 1 or RHO must be set equal to 1.0. See Table 16 for further explanation of the input data for MPPROG.

The negative $\Delta M/\Delta \log D$ and $\Delta N/\Delta \log D$ values which occur on the U of W and MRI printouts result from the D_{50} of stage 2 being larger than the D_{50} of stage 1. This occurs because the measured $\sqrt{\psi}$ calibration constant for stage 1 is significantly different from the ideal value of 0.38 predicted by Ranz and Wong.[7]

Stage calibration constants for these impactors were reported by K. Cushing et al., in EPA Report 600/2-76-280, Particulate Sizing Techniques for Control Device Evaluation: Cascade Impactor Calibrations. For this reason, when curve fits are made, stage catches for the first two stages of Andersen, U of W, and MRI impactors are automatically combined. This was discussed earlier in Section 2.

The second part of the example calculations uses the entire cascade impactor data reduction system. Programs MPPROG, SPLIN1, GRAPH, and STATIS are executed for data taken at the inlet and outlet of a control device. These data were taken with Brink and Andersen impactors. Next, programs PENTRA and PENLOG are used to calculate penetration-efficiency information. As with the first part of this section, data decks are included before the results.

Graphs are included along with printouts. These graphs are usually located after the printout containing the data to be plotted. Representative fits are shown for single inlet and outlet impactor runs. In these graphs, raw data are shown as small squares. Two graphs are included in which raw cumulative mass loading information is overlaid to show the grouping of data taken under the same conditions. One graph contains inlet data; the other graph contains outlet data. Other graphs show averaged inlet and outlet data and penetration-efficiency results from PENTRA and PENLOG. Note that in the plot produced by PENLOG that efficiencies less than 90% are plotted slightly off the edge of the plotting grid.

CARD COLUMN
NUMBERS

DATA DECK FOR PROGRAM MPPROG

```
         11111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
--------------------------------------------------------------------------------
0100
CIDRS VERSION 1 TEST FOR ANDERSEN.
03
30.06 280.0 280.02.40 60.0 50.00001
 .14   .00   .80   .06   .08
  0.54  0.39  1.90  4.39  1.53  0.18  0.58  0.29  1.22
  .358
HYPOTHETICAL ANDERSEN
00
```

```
HYPOTHETICAL ANDERSEN

IMPACTOR FLOWRATE = 0.358 ACFM            IMPACTOR TEMPERATURE =  280.0 F = 137.8 C            SAMPLING DURATION =  60.00 MIN

IMPACTOR PRESSURE DROP = 0.2 IN. OF HG    STACK TEMPERATURE =  280.0 F = 137.8 C

ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.    STACK PRESSURE = 30.06 IN. OF HG    MAX. PARTICLE DIAMETER =  50.0 MICROMETERS

GAS COMPOSITION (PERCENT)          CO2 = 12.88          CO =  0.00          N2 = 73.60          O2 =  5.52          H2O =  8.00

CALC. MASS LOADING = 7.9174E-03 GR/ACF           1.1968E-02 GR/DNCF              1.8118E+01 MG/ACM              2.7387E+01 MG/DNCM

IMPACTOR STAGE                            S1        S2        S3        S4        S5        S6        S7        S8       FILTER

STAGE INDEX NUMBER                         1         2         3         4         5         6         7         8         9

D50 (MICROMETERS)                        9.17      8.67      5.26      3.63      1.84      0.86      0.55      0.27

MASS (MILLIGRAMS)                        1.22      0.29      0.58      0.18      1.53      4.39      1.90      0.39      0.54

MG/DNCM/STAGE                          3.03E+00  7.21E-01  1.44E+00  4.47E-01  3.80E+00  1.09E+01  4.72E+00  9.69E-01  1.34E+00

CUM. PERCENT OF MASS SMALLER THAN D50  88.93     86.30     81.03     79.40     65.52     25.68     8.44      4.90

CUM. (MG/ACM) SMALLER THAN D50         1.61E+01  1.56E+01  1.47E+01  1.44E+01  1.19E+01  4.65E+00  1.53E+00  8.88E-01

CUM. (MG/DNCM) SMALLER THAN D50        2.44E+01  2.36E+01  2.22E+01  2.17E+01  1.79E+01  7.03E+00  2.31E+00  1.34E+00

CUM. (GR/ACF) SMALLER THAN D50         7.04E-03  6.83E-03  6.42E-03  6.29E-03  5.19E-03  2.03E-03  6.68E-04  3.88E-04

CUM. (GR/DNCF) SMALLER THAN D50        1.06E-02  1.03E-02  9.70E-03  9.50E-03  7.84E-03  3.07E-03  1.01E-03  5.86E-04

GEO. MEAN DIA. (MICROMETERS)           2.14E+01  8.91E+00  6.75E+00  4.37E+00  2.58E+00  1.26E+00  6.87E-01  3.87E-01  1.94E-01

DM/DLOGD (MG/DNCM)                     4.12E+00  2.97E+01  6.65E+00  2.77E+00  1.29E+01  3.33E+01  2.37E+01  3.24E+00  4.46E+00

DN/DLOGD (NO. PARTICLES/DNCM)          3.34E+05  3.34E+07  1.72E+07  2.64E+07  5.96E+08  1.33E+10  5.83E+10  4.45E+10  4.88E+11


NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
```

```
HYPOTHETICAL ANDERSEN

IMPACTOR FLOWRATE = 0,358 ACFM              IMPACTOR TEMPERATURE =  280,0 F = 137,8 C             SAMPLING DURATION =  60,00 MIN

IMPACTOR PRESSURE DROP = 0,2 IN, OF HG       STACK TEMPERATURE =  280,0 F = 137,8 C

ASSUMED PARTICLE DENSITY = 1,00 GM/CU,CM,     STACK PRESSURE = 30,06 IN, OF HG     MAX, PARTICLE DIAMETER =  77,5 MICROMETERS

GAS COMPOSITION (PERCENT)          CO2 = 12,88          CO =  0,00           N2 = 73,60           O2 =  5,52           H2O =  8,00

CALC, MASS LOADING = 7,9174E-03 GR/ACF            1,1968E-02 GR/DNCF             1,8118E+01 MG/ACM             2,7387E+01 MG/DNCM

IMPACTOR STAGE                          S1         S2         S3         S4         S5         S6         S7         S8       FILTER

STAGE INDEX NUMBER                       1          2          3          4          5          6          7          8          9

D50 (MICROMETERS)                      14,37      13,60       8,32       5,79       3,01       1,50       1,01       0,58

MASS (MILLIGRAMS)                       1,22       0,29       0,58       0,18       1,53       4,39       1,90       0,39       0,54

MG/DNCM/STAGE                         3,03E+00  7,21E-01  1,44E+00  4,47E-01  3,80E+00  1,09E+01  4,72E+00  9,69E-01  1,34E+00

CUM, PERCENT OF MASS SMALLER THAN D50  88,93      86,30      81,03      79,40      65,52      25,68       8,44       4,90

CUM, (MG/ACM) SMALLER THAN D50        1,61E+01  1,56E+01  1,47E+01  1,44E+01  1,19E+01  4,65E+00  1,53E+00  8,88E-01

CUM, (MG/DNCM) SMALLER THAN D50       2,44E+01  2,36E+01  2,22E+01  2,17E+01  1,79E+01  7,03E+00  2,31E+00  1,34E+00

CUM, (GR/ACF) SMALLER THAN D50        7,04E-03  6,83E-03  6,42E-03  6,29E-03  5,19E-03  2,03E-03  6,68E-04  3,88E-04

CUM, (GR/DNCF) SMALLER THAN D50       1,06E-02  1,03E-02  9,70E-03  9,50E-03  7,84E-03  3,07E-03  1,01E-03  5,86E-04

GEO, MEAN DIA, (MICROMETERS)          3,34E+01  1,40E+01  1,06E+01  6,94E+00  4,17E+00  2,13E+00  1,23E+00  7,66E-01  4,12E-01

DM/DLOGD (MG/DNCM)                    4,14E+00  3,01E+01  6,76E+00  2,83E+00  1,34E+01  3,61E+01  2,72E+01  4,08E+00  4,46E+00

DN/DLOGD (NO, PARTICLES/DNCM)         2,13E+05  2,10E+07  1,07E+07  1,62E+07  3,52E+08  7,18E+09  2,80E+10  1,74E+10  1,22E+11


NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO MERCER,
HYPOTHETICAL ANDERSEN

IMPACTOR FLOWRATE = 0.358 ACFM              IMPACTOR TEMPERATURE =  280.0 F = 137.8 C              SAMPLING DURATION =  60.00 MIN

IMPACTOR PRESSURE DROP = 0.2 IN. OF HG      STACK TEMPERATURE =  280.0 F = 137.8 C

ASSUMED PARTICLE DENSITY = 1.00 GM/CU.CM.    STACK PRESSURE = 30.06 IN. OF HG     MAX. PARTICLE DIAMETER =  77.5 MICROMETERS

GAS COMPOSITION (PERCENT)           CO2 = 12.88          CO =  0.00          N2 = 73.60          O2 =  5.52          H2O =  8.00

CALC. MASS LOADING = 7.9174E-03 GR/ACF             1.1968E-02 GR/DNCF             1.8118E+01 MG/ACM             2.7387E+01 MG/DNCM

IMPACTOR STAGE                              S1        S2        S3        S4        S5        S6        S7        S8       FILTER

STAGE INDEX NUMBER                           1         2         3         4         5         6         7         8         9

D50 (MICROMETERS)                         14.26     13.49      8.21      5.68      2.90      1.39      0.90      0.48

MASS (MILLIGRAMS)                          1.22      0.29      0.58      0.18      1.53      4.39      1.90      0.39      0.54

MG/DNCM/STAGE                          3.03E+00  7.21E-01  1.44E+00  4.47E-01  3.80E+00  1.09E+01  4.72E+00  9.69E-01  1.34E+00

CUM. PERCENT OF MASS SMALLER THAN D50  88.93     86.30     81.03     79.40     65.52     25.68      8.44      4.90

CUM. (MG/ACM) SMALLER THAN D50         1.61E+01  1.56E+01  1.47E+01  1.44E+01  1.19E+01  4.65E+00  1.53E+00  8.88E-01

CUM. (MG/DNCM) SMALLER THAN D50        2.44E+01  2.36E+01  2.22E+01  2.17E+01  1.79E+01  7.03E+00  2.31E+00  1.34E+00

CUM. (GR/ACF) SMALLER THAN D50         7.04E-03  6.83E-03  6.42E-03  6.29E-03  5.19E-03  2.03E-03  6.68E-04  3.88E-04

CUM. (GR/DNCF) SMALLER THAN D50        1.06E-02  1.03E-02  9.70E-03  9.50E-03  7.84E-03  3.07E-03  1.01E-03  5.86E-04

GEO. MEAN DIA. (MICROMETERS)           3.32E+01  1.39E+01  1.05E+01  6.83E+00  4.06E+00  2.01E+00  1.12E+00  6.57E-01  3.39E-01

DM/DLOGD (MG/DNCM)                     4.13E+00  2.98E+01  6.69E+00  2.79E+00  1.30E+01  3.43E+01  2.49E+01  3.53E+00  4.46E+00

DN/DLOGD (NO. PARTICLES/DNCM)          2.15E+05  2.13E+07  1.10E+07  1.67E+07  3.73E+08  8.05E+09  3.38E+10  2.38E+10  2.19E+11


NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.

AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO THE TASK GROUP ON LUNG DYNAMICS.
STOP  000000
```

DATA DECK FOR PROGRAM HPPROG

CARD COLUMN
NUMBERS

```
         11111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
--------------------------------------------------------------------------------
0200
CIDRS VERSION 1 TEST FOR BRINK.
03
29.50 330.0 330.02.40 15.0168.01161
 .1400 .0000 .8000 .0600 .0800
 0.19  0.10  0.30  1.18  1.63  2.16  2.90  6.12 39.38
 0.0310
HYPOTHETICAL BRINK TEST - CYC, STAGE 0 - STAGE 6, FILTER
03
29.50 330.0 330.02.40 15.0168.01151
 .1400 .0000 .8000 .0600 .0800
 0.19  0.00  0.30  1.18  1.63  2.16  2.90  6.12 39.38
 0.0310
HYPOTHETICAL BRINK TEST - CYC, STAGE 0 - STAGE 5, FILTER
03
30.00 300.0 300.02.40 15.0168.01160
 .1400 .0000 .8000 .0600 .0800
 0.00  0.10  0.30  1.18  1.63  2.16  2.90  6.12 39.38
 0.0310
HYPOTHETICAL BRINK TEST - CYC, STAGE 0 - STAGE 6, NO FILTER
03
30.00 300.0 300.02.40 15.0168.01150
 .1400 .0000 .8000 .0600 .0800
 0.00  0.00  0.30  1.18  1.63  2.16  2.90  6.12 39.38
 0.0310
HYPOTHETICAL BRINK TEST - CYC, STAGE 0 - STAGE 5, NO FILTER
03
29.50 330.0 330.02.40 15.0168.00161
 .1400 .0000 .8000 .0600 .0800
 0.19  0.10  0.30  1.18  1.63  2.16  2.90  6.12  0.00
 0.0310
HYPOTHETICAL BRINK TEST - STAGE 0 - STAGE 6, FILTER
03
```

```
30.00 300.0 300.02.40 15.0168.00151
 .1400 .0000 .8000 .0600 .0800
 0.19  0.00  0.30  1.18  1.63  2.16  2.90  6.12  0.00
 0.0310
HYPOTHETICAL BRINK TEST - STAGE 0 - STAGE 5, FILTER
03
30.00 300.0 300.02.40 15.0168.00160
 .1400 .0000 .8000 .0600 .0800
 0.00  0.10  0.30  1.18  1.63  2.16  2.90  6.12  0.00
 0.0310
HYPOTHETICAL BRINK TEST - STAGE 0 - STAGE 6, NO FILTER
03
30.00 300.0 300.02.40 15.0168.00150
 .1400 .0000 .8000 .0600 .0800
 0.00  0.00  0.30  1.18  1.63  2.16  2.90  6.12  0.00
 0.0310
HYPOTHETICAL BRINK TEST - STAGE 0 - STAGE 5, NO FILTER
03
29.50 330.0 330.02.40 15.0168.00061
 .1400 .0000 .8000 .0600 .0800
 0.19  0.10  0.30  1.18  1.63  2.16  2.90  0.00  0.00
 0.0310
HYPOTHETICAL BRINK TEST - STAGE 1 - STAGE 6, FILTER
03
30.00 300.0 300.02.40 15.0168.00051
 .1400 .0000 .8000 .0600 .0800
 0.19  0.00  0.30  1.18  1.63  2.16  2.90  0.00  0.00
 0.0310
HYPOTHETICAL BRINK TEST - STAGE 1 - STAGE 5, FILTER
03
30.00 300.0 300.02.40 15.0168.00060
 .1400 .0000 .8000 .0600 .0800
 0.00  0.10  0.30  1.18  1.63  2.16  2.90  0.00  0.00
 0.0310
HYPOTHETICAL BRINK TEST - STAGE 1 - STAGE 6, NO FILTER
03
30.00 300.0 300.02.40 15.0168.00050
 .1400 .0000 .8000 .0600 .0800
 0.00  0.00  0.30  1.18  1.63  2.16  2.90  0.00  0.00
 0.0310
HYPOTHETICAL BRINK TEST - STAGE 1 - STAGE 5, NO FILTER
00
```

```
HYPOTHETICAL BRINK TEST - CYC, STAGE 0 - STAGE 6, FILTER

IMPACTOR FLOWRATE = 0.031 ACFM              IMPACTOR TEMPERATURE =  330.0 F = 165.6 C            SAMPLING DURATION =  15.00 MIN

IMPACTOR PRESSURE DROP = 1.2 IN. OF HG       STACK TEMPERATURE =  330.0 F = 165.6 C

ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.     STACK PRESSURE = 29.50 IN. OF HG     MAX. PARTICLE DIAMETER = 168.0 MICROMETERS

GAS COMPOSITION (PERCENT)           CO2 = 12.88          CO =  0.00           N2 = 73.60           O2 =  5.52           H2O =  8.00

CALC. MASS LOADING = 1.7908E+00 GR/ACF            2.9450E+00 GR/DNCF            4.0980E+03 MG/ACM            6.7391E+03 MG/DNCM

IMPACTOR STAGE                            CYC        S0         S1         S2         S3         S4         S5         S6      FILTER

STAGE INDEX NUMBER                          1          2          3          4          5          6          7          8          9

D50 (MICROMETERS)                        11.00       6.68       3.63       2.28       1.74       0.73       0.53       0.25

MASS (MILLIGRAMS)                        39.38       6.12       2.90       2.16       1.63       1.18       0.30       0.10       0.19

MG/DNCM/STAGE                            4.92E+03  7.64E+02  3.62E+02  2.70E+02  2.04E+02  1.47F+02  3.75E+01  1.25E+01  2.37E+01

CUM. PERCENT OF MASS SMALLER THAN D50  27.02      15.68      10.30       6.30       3.28       1.09       0.54       0.35

CUM. (MG/ACM) SMALLER THAN D50           1.11E+03  6.42E+02  4.22E+02  2.58E+02  1.34E+02  4.48E+01  2.20E+01  1.44E+01

CUM. (MG/DNCM) SMALLER THAN D50          1.82E+03  1.06E+03  6.94E+02  4.25E+02  2.21E+02  7.37E+01  3.62E+01  2.37F+01

CUM. (GR/ACF) SMALLER THAN D50           4.84E-01  2.81E-01  1.85E-01  1.13F-01  5.87E-02  1.96E-02  9.62E-03  6.31E-03

CUM. (GR/DNCF) SMALLER THAN D50          7.96E-01  4.62E-01  3.03E-01  1.86E-01  9.66E-02  3.22E-02  1.58E-02  1.04E-02

GEO. MEAN DIA. (MICROMETERS)             4.30F+01  8.57E+00  4.92E+00  2.88E+00  1.99E+00  1.13E+00  6.20E-01  3.63E-01  1.76E-01

DM/DLOGD (MG/DNCM)                       4.15E+03  3.53E+03  1.37E+03  1.33E+03  1.73E+03  3.90E+02  2.67E+02  3.84E+01  7.88E+01

DN/DLOGD (NO. PARTICLES/DNCM)            4.16E+07  4.46E+09  9.11E+09  4.46E+10  1.75E+11  2.18E+11  8.91E+11  6.40E+11  1.14E+13


NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
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HYPOTHETICAL BRINK TEST - CYC, STAGE 0 - STAGF 6, FILTER
IMPACTOR FLOWRATE = 0,031 ACFM              IMPACTOR TEMPERATURE =  330.0 F = 165.6 C               SAMPLING DURATION =  15,00 MIN
IMPACTOR PRESSURE DROP = 1.2 IN. OF HG      STACK TEMPERATURE =  330.0 F = 165.6 C
ASSUMED PARTICLE DENSITY = 1.00 GM/CU.CM.     STACK PRESSURE = 29.50 IN. OF HG     MAX. PARTICLE DIAMETER = 260,3 MICROMETERS
GAS COMPOSITION (PERCENT)          CO2 = 12.88          CO =  0.00           N2 = 73,60          O2 =  5,52           H2O =  8,00
CALC. MASS LOADING = 1,7908E+00 GR/ACF            2,9450E+00 GR/DNCF              4,0980E+03 MG/ACM              6,7391E+03 MG/DNCM
IMPACTOR STAGE                              CYC        S0         S1         S2         S3         S4         S5         S6      FILTER
STAGE INDEX NUMBER                            1          2          3          4          5          6          7          8          9
D50 (MICROMETERS)                          17,04      10,54      5,81       3,72       2,88       1,31       1,00       0,57
MASS (MILLIGRAMS)                          39,38      6,12       2,90       2,16       1,63       1,18       0,30       0,10       0,19
MG/DNCM/STAGE                            4,92E+03  7,64F+02  3,62E+02  2,70E+02  2,04E+02  1,47E+02  3,75E+01  1,25E+01  2,37E+01
CUM. PERCENT OF MASS SMALLER THAN D50    27,02      15,68      10,30      6,30       3,28       1,09       0,54       0,35
CUM. (MG/ACM) SMALLER THAN D50           1,11E+03  6,42E+02  4,22E+02  2,58E+02  1,34E+02  4,48E+01  2,20E+01  1,44E+01
CUM. (MG/DNCM) SMALLER THAN D50          1,82E+03  1,06E+03  6,94E+02  4,25E+02  2,21E+02  7,37E+01  3,62E+01  2,37E+01
CUM. (GR/ACF) SMALLER THAN D50           4,84E-01  2,81E-01  1,85E-01  1,13E-01  5,87E-02  1,96E-02  9,62E-03  6,31E-03
CUM. (GR/DNCF) SMALLER THAN D50          7,96E-01  4,62E-01  3,03E-01  1,86E-01  9,66E-02  3,22E-02  1,58E-02  1,04F-02
GEO. MEAN DIA. (MICROMETERS)             6,66E+01  1,34E+01  7,83E+00  4,65E+00  3,27E+00  1,94E+00  1,14E+00  7,\0E-01  4,00E-01
DM/DLOGD (MG/DNCM)                       4,15E+03  3,66E+03  1,40E+03  1,39E+03  1,83E+03  4,30E+02  3,16E+02  5,09E+01  7,88E+01
DN/DLOGD (NO. PARTICLES/DNCM)            2,69E+07  2,91E+09  5,58E+09  2,64E+10  1,00E+11  1,13E+11  4,06E+11  1,30E+11  2,35E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO MERCER.
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HYPOTHETICAL BRINK TEST - CYC, STAGE 0 - STAGE 6, FILTER
IMPACTOR FLOWRATE = 0.031 ACFM            IMPACTOR TEMPERATURE =  330.0 F = 165.6 C                SAMPLING DURATION =  15.00 MIN
IMPACTOR PRESSURE DROP = 1.2 IN. OF HG     STACK TEMPERATURE =  330.0 F = 165.6 C
ASSUMED PARTICLE DENSITY = 1.00 GM/CU.CM.   STACK PRESSURE = 29.50 IN. OF HG    MAX. PARTICLE DIAMETER = 260.3 MICROMETERS
GAS COMPOSITION (PERCENT)          CO2 = 12.88          CO =  0.00          N2 = 73.60          O2 =  5.52          H2O =  8.00
CALC. MASS LOADING = 1.7908E+00 GR/ACF          2.9450E+00 GR/DNCF          4.0980E+03 MG/ACM          6.7391E+03 MG/DNCM
IMPACTOR STAGE                          CYC       S0        S1        S2        S3        S4        S5        S6      FILTER
STAGE INDEX NUMBER                       1         2         3         4         5         6         7         8         9
D50 (MICROMETERS)                      17.04     10.42      5.69      3.60      2.76      1.19      0.88      0.45
MASS (MILLIGRAMS)                      39.38      6.12      2.90      2.16      1.63      1.18      0.30      0.10      0.19
MG/DNCM/STAGE                        4.92E+03  7.64E+02  3.62E+02  2.70E+02  2.04E+02  1.47E+02  3.75E+01  1.25E+01  2.37E+01
CUM. PERCENT OF MASS SMALLER THAN D50  27.02     15.68     10.30      6.30      3.28      1.09      0.54      0.35
CUM. (MG/ACM) SMALLER THAN D50       1.11E+03  6.42E+02  4.22E+02  2.58E+02  1.34E+02  4.48E+01  2.20E+01  1.44E+01
CUM. (MG/DNCM) SMALLER THAN D50      1.82E+03  1.06E+03  6.94E+02  4.25E+02  2.21E+02  7.37E+01  3.62E+01  2.37E+01
CUM. (GR/ACF) SMALLER THAN D50       4.84E-01  2.81E-01  1.85E-01  1.13E-01  5.87E-02  1.96E-02  9.62E-03  6.31E-03
CUM. (GR/DNCF) SMALLER THAN D50      7.96E-01  4.62E-01  3.03E-01  1.86E-01  9.66E-02  3.22E-02  1.58E-02  1.04E-02
GEO. MEAN DIA. (MICROMETERS)         6.66E+01  1.33E+01  7.70E+00  4.52E+00  3.15E+00  1.81E+00  1.02E+00  6.27E-01  3.16E-01
DM/DLOGD (MG/DNCM)                   4.15E+03  3.58E+03  1.38E+03  1.35E+03  1.77E+03  4.04E+02  2.84E+02  4.26E+01  7.88E+01
DN/DLOGD (NO. PARTICLES/DNCM)        2.69E+07  2.89E+09  5.77E+09  2.79E+10  1.08E+11  1.30E+11  5.07E+11  3.30E+11  4.75E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO THE TASK GROUP ON LUNG DYNAMICS.
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HYPOTHETICAL BRINK TEST - CYC, STAGE 0 - STAGE 5, FILTER
IMPACTOR FLOWRATE = 0.031 ACFM              IMPACTOR TEMPERATURE =  330.0 F = 165.6 C             SAMPLING DURATION =  15.00 MIN
IMPACTOR PRESSURE DROP = 0.4 IN. OF HG      STACK TEMPERATURE =  330.0 F = 165.6 C
ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.    STACK PRESSURE = 29.50 IN. OF HG     MAX. PARTICLE DIAMETER = 168.0 MICROMETERS
GAS COMPOSITION (PERCENT)          CO2 = 12.88         CO =  0.00          N2 = 73.60          O2 =  5.52             H2O =  8.00
CALC. MASS LOADING = 1.7875E+00 GR/ACF            2.9395E+00 GR/DNCF            4.0904E+03 MG/ACM              6.7266E+03 MG/DNCM
IMPACTOR STAGE                                CYC       S0        S1        S2        S3        S4        S5                 FILTER
STAGE INDEX NUMBER                             1         2         3         4         5         6         7                   8
D50 (MICROMETERS)                            11.00      6.68      3.63      2.28      1.74      0.73      0.53
MASS (MILLIGRAMS)                            39.38      6.12      2.90      2.16      1.63      1.18      0.30                0.19
MG/DSCM/STAGE                               4.92E+03  7.64E+02  3.62E+02  2.70E+02  2.04E+02  1.47E+02  3.75E+01           2.37E+01
CUM. PERCENT OF MASS SMALLER THAN D50       26.88     15.52     10.14      6.13      3.10      0.91      0.35
CUM. (MG/ACM) SMALLER THAN D50              1.10E+03  6.35E+02  4.15E+02  2.51E+02  1.27E+02  3.72E+01  1.44E+01
CUM. (MG/DNCM) SMALLER THAN D50             1.81E+03  1.04E+03  6.82E+02  4.12E+02  2.09E+02  6.12E+01  2.37E+01
CUM. (GR/ACF) SMALLER THAN D50              4.81E-01  2.77E-01  1.81E-01  1.10E-01  5.54E-02  1.63E-02  6.31E-03
CUM. (GR/DNCF) SMALLER THAN D50             7.90E-01  4.56E-01  2.98E-01  1.80E-01  9.11E-02  2.67E-02  1.04E-02
GEO. MEAN DIA. (MICROMETERS)                4.30E+01  8.57E+00  4.92E+00  2.88E+00  1.99E+00  1.13E+00  6.21E-01           1.82E-01
DM/DLOGD (MG/DNCM)                          4.15E+03  3.53E+03  1.37E+03  1.33E+03  1.73E+03  3.91E+02  2.69E+02           7.88E+01
DN/DLOGD (NO. PARTICLES/DNCM)               4.16E+07  4.46E+09  9.11E+09  4.46E+10  1.75E+11  2.17E+11  8.91E+11           1.04E+13

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
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HYPOTHETICAL BRINK TEST - CYC, STAGE 0 - STAGE 5, FILTER
IMPACTOR FLOWRATE = 0.031 ACFM              IMPACTOR TEMPERATURE =  330.0 F = 165.6 C             SAMPLING DURATION =  15.00 MIN
IMPACTOR PRESSURE DROP = 0.4 IN. OF HG      STACK TEMPERATURE =  330.0 F = 165.6 C
ASSUMED PARTICLE DENSITY = 1.00 GM/CU.CM.    STACK PRESSURE = 29.50 IN. OF HG    MAX. PARTICLE DIAMETER = 260.3 MICROMETERS
GAS COMPOSITION (PERCENT)          CO2 = 12.88          CO =  0.00          N2 = 73.60          O2 =  5.52          H2O =  8.00
CALC. MASS LOADING = 1.7875E+00 GR/ACF            2.9395E+00 GR/DNCF            4.0904E+03 MG/ACM            6.7266E+03 MG/DNCM
IMPACTOR STAGE                             CYC        S0        S1        S2        S3        S4        S5                FILTER
STAGE INDEX NUMBER                          1          2         3         4         5         6         7                  8
D50 (MICROMETERS)                         17.04      10.54      5.81      3.72      2.88      1.31      1.00
MASS (MILLIGRAMS)                         39.38       6.12      2.90      2.16      1.63      1.18      0.30               0.19
MG/DSCM/STAGE                            4.92E+03  7.64E+02  3.62E+02  2.70E+02  2.04E+02  1.47E+02  3.75E+01          2.37E+01
CUM. PERCENT OF MASS SMALLER THAN D50    26.88      15.52     10.14      6.13      3.10      0.91      0.35
CUM. (MG/ACM) SMALLER THAN D50           1.10E+03  6.35E+02  4.15E+02  2.51E+02  1.27E+02  3.72E+01  1.44E+01
CUM. (MG/DNCM) SMALLER THAN D50          1.81E+03  1.04E+03  6.82E+02  4.12E+02  2.09E+02  6.12E+01  2.37E+01
CUM. (GR/ACF) SMALLER THAN D50           4.81E-01  2.77E-01  1.81E-01  1.10E-01  5.54E-02  1.63E-02  6.31E-03
CUM. (GR/DNCF) SMALLER THAN D50          7.90E-01  4.56E-01  2.98E-01  1.80E-01  9.11E-02  2.67E-02  1.04E-02
GEO. MEAN DIA. (MICROMETERS)             6.66E+01  1.34E+01  7.83E+00  4.65E+00  3.27E+00  1.94E+00  1.14E+00          4.05E-01
DM/DLOGD (MG/DNCM)                       4.15E+03  3.66E+03  1.40E+03  1.39E+03  1.83E+03  4.31E+02  3.17E+02          7.88E+01
DN/DLOGD (NO. PARTICLES/DNCM)            2.69E+07  2.91E+09  5.58E+09  2.64E+10  1.00E+11  1.12E+11  4.06E+11          2.26E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO MERCER.
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HYPOTHETICAL BRINK TEST - CYC, STAGE 0 - STAGE 5, FILTER
IMPACTOR FLOWRATE = 0.031 ACFM            IMPACTOR TEMPERATURE =  330.0 F = 165.6 C            SAMPLING DURATION =  15.00 MIN
IMPACTOR PRESSURE DROP = 0.4 IN. OF HG    STACK TEMPERATURE =  330.0 F = 165.6 C
ASSUMED PARTICLE DENSITY = 1.00 GM/CU.CM.  STACK PRESSURE = 29.50 IN. OF HG    MAX. PARTICLE DIAMETER = 260.3 MICROMETERS
GAS COMPOSITION (PERCENT)            CO2 = 12.88          CO =  0.00           N2 = 73.60          O2 =  5.52          H2O =  8.00
CALC. MASS LOADING = 1.7875E+00 GR/ACF             2.9395E+00 GR/DNCF           4.0904E+03 MG/ACM             6.7266E+03 MG/DNCM
IMPACTOR STAGE                                CYC       S0        S1        S2        S3        S4        S5              FILTER
STAGE INDEX NUMBER                             1         2         3         4         5         6         7                 8
D50 (MICROMETERS)                            17.04     10.42     5.69      3.60      2.76      1.19      0.88
MASS (MILLIGRAMS)                            39.38     6.12      2.90      2.16      1.63      1.18      0.30              0.19
MG/DSCM/STAGE                               4.92E+03  7.64E+02  3.62E+02  2.70E+02  2.04E+02  1.47E+02  3.75E+01          2.37E+01
CUM. PERCENT OF MASS SMALLER THAN D50        26.88     15.52     10.14     6.13      3.10      0.91      0.35
CUM. (MG/ACM) SMALLER THAN D50              1.10E+03  6.35E+02  4.15E+02  2.51E+02  1.27E+02  3.72E+01  1.44E+01
CUM. (MG/DNCM) SMALLER THAN D50             1.81E+03  1.04E+03  6.82E+02  4.12E+02  2.09E+02  6.12E+01  2.37E+01
CUM. (GR/ACF) SMALLER THAN D50              4.81E-01  2.77E-01  1.81E-01  1.10E-01  5.54E-02  1.63E-02  6.31E-03
CUM. (GR/DNCF) SMALLER THAN D50             7.90E-01  4.56E-01  2.98E-01  1.80E-01  9.11E-02  2.67E-02  1.04E-02
GEO. MEAN DIA. (MICROMETERS)                6.66E+01  1.33E+01  7.70E+00  4.52E+00  3.15E+00  1.81E+00  1.02E+00          3.24E-01
DM/DLOGD (MG/DNCM)                          4.15E+03  3.58E+03  1.38E+03  1.35E+03  1.77E+03  4.04E+02  2.86E+02          7.88E+01
DN/DLOGD (NO. PARTICLES/DNCM)               2.69E+07  2.89E+09  5.77E+09  2.79E+10  1.08E+11  1.30E+11  5.07E+11          4.44E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO THE TASK GROUP ON LUNG DYNAMICS.
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HYPOTHETICAL BRINK TEST - CYC, STAGE 0 - STAGE 6, NO FILTER
IMPACTOR FLOWRATE = 0,031 ACFM              IMPACTOR TEMPERATURE =  300,0 F = 148,9 C             SAMPLING DURATION =  15,00 MIN
IMPACTOR PRESSURE DROP = 1.2 IN, OF HG      STACK TEMPERATURE =  300,0 F = 148,9 C
ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM,     STACK PRESSURE = 30,00 IN, OF HG     MAX, PARTICLE DIAMETER = 168,0 MICROMETERS
GAS COMPOSITION (PERCENT)          CO2 = 12,88         CO =  0,00            N2 = 73,60          O2 =  5,52          H2O =  8,00
CALC, MASS LOADING = 1,7845E+00 GR/ACF            2,7760E+00 GR/DNCF              4,0836E+03 MG/ACM              6,3525E+03 MG/DNCM
IMPACTOR STAGE                                CYC        S0        S1        S2        S3        S4        S5        S6      FILTER
STAGE INDEX NUMBER                              1         2         3         4         5         6         7         8         9
D50 (MICROMETERS)                           10,84      6,59      3,58      2,25      1,72      0,72      0,53      0,25
MASS (MILLIGRAMS)                           39,38      6,12      2,90      2,16      1,63      1,18      0,30      0,10      0,00
MG/DNCM/STAGE                            4,65E+03  7,23E+02  3,43E+02  2,55E+02  1,93E+02  1,39E+02  3,54E+01  1,18E+01  0,00E 01
CUM, PERCENT OF MASS SMALLER THAN D50   26,76     15,35      9,99      5,97      2,94      0,74      0,19      0,00
CUM, (MG/ACM) SMALLER THAN D50           1,09E+03  6,28E+02  4,08E+02  2,44E+02  1,20E+02  3,04E+01  7,59E+00  0,00E-01
CUM, (MG/DNCM) SMALLER THAN D50          1,70E+03  9,77E+02  6,34E+02  3,79E+02  1,87E+02  4,73E+01  1,18E+01  0,00E-01
CUM, (GR/ACF) SMALLER THAN D50           4,78E-01  2,74E-01  1,78E-01  1,07E-01  5,24E-02  1,33E-02  3,32E-03  0,00E-01
CUM, (GR/DNCF) SMALLER THAN D50          7,43E-01  4,27E-01  2,77E-01  1,66E-01  8,16E-02  2,07E-02  5,16E-03  0,00E-01
GEO, MEAN DIA, (MICROMETERS)             4,27E+01  8,45E+00  4,86E+00  2,84E+00  1,97E+00  1,12E+00  6,17E-01  3,63E-01  1,77E-01
DM/DLOGD (MG/DNCM)                       3,91E+03  3,35E+03  1,30E+03  1,26E+03  1,64E+03  3,71E+02  2,55E+02  3,68E+01  0,00E-01
DN/DLOGD (NO, PARTICLES/DNCM)            4,00E+07  4,41E+09  8,98E+09  4,39E+10  1,72E+11  2,13E+11  8,65E+11  6,12E+11  0,00E-01

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
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HYPOTHETICAL BRINK TEST - CYC, STAGE 0 - STAGE 6, NO FILTER
IMPACTOR FLOWRATE = 0.031 ACFM              IMPACTOR TEMPERATURE =  300.0 F = 148.9 C              SAMPLING DURATION =  15.00 MIN
IMPACTOR PRESSURE DROP = 1.2 IN. OF HG      STACK TEMPERATURE =  300.0 F = 148.9 C
ASSUMED PARTICLE DENSITY = 1.00 GM/CU.CM.     STACK PRESSURE = 30.00 IN. OF HG     MAX. PARTICLE DIAMETER = 260.3 MICROMETERS
GAS COMPOSITION (PERCENT)          CO2 = 12.88          CO =  0.00          N2 = 73.60          O2 =  5.52          H2O =  8.00
CALC. MASS LOADING = 1.7845E+00 GR/ACF           2.7760E+00 GR/DNCF           4.0836E+03 MG/ACM           6.3525E+03 MG/DNCM
IMPACTOR STAGE                             CYC        S0         S1         S2         S3         S4         S5         S6       FILTER
STAGE INDEX NUMBER                           1          2          3          4          5          6          7          8          9
D50 (MICROMETERS)                        16.79      10.38      5.73       3.66       2.84       1.29       0.98       0.56
MASS (MILLIGRAMS)                        39.38       6.12      2.90       2.16       1.63       1.18       0.30       0.10       0.00
MG/DNCM/STAGE                             4.65E+03  7.23E+02  3.43E+02  2.55E+02  1.93E+02  1.39E+02  3.54E+01  1.18E+01  0.00E-01
CUM. PERCENT OF MASS SMALLER THAN D50    26.76      15.38      9.99       5.97       2.94       0.74       0.19       0.00
CUM. (MG/ACM) SMALLER THAN D50            1.09E+03  6.28E+02  4.08E+02  2.44E+02  1.20E+02  3.04E+01  7.59E+00  0.00E-01
CUM. (MG/DNCM) SMALLER THAN D50           1.70E+03  9.77E+02  6.34E+02  3.79E+02  1.87E+02  4.73E+01  1.18E+01  0.00E-01
CUM. (GR/ACF) SMALLER THAN D50            4.78E-01  2.74E-01  1.78E-01  1.07E-01  5.24E-02  1.33E-02  3.32E-03  0.00E-01
CUM. (GR/DNCF) SMALLER THAN D50           7.43E-01  4.27E-01  2.77E-01  1.66E-01  8.16E-02  2.07E-02  5.16E-03  0.00E-01
GEO. MEAN DIA. (MICROMETERS)              6.61E+01  1.32E+01  7.71E+00  4.58E+00  3.22E+00  1.91E+00  1.12E+00  7.39E-01  3.94E-01
DM/DLOGD (MG/DNCM)                        3.91E+03  3.47E+03  1.33E+03  1.31E+03  1.73E+03  4.07E+02  2.99E+02  4.81E+01  0.00E-01
DN/DLOGD (NO. PARTICLES/DNCM)             2.58E+07  2.88E+09  5.52E+09  2.61E+10  9.90E+10  1.11E+11  4.01E+11  2.28E+11  0.00E-01


NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO MERCER.
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HYPOTHETICAL BRINK TEST - CYC, STAGE 0 - STAGE 6, NO FILTER
IMPACTOR FLOWRATE = 0.031 ACFM              IMPACTOR TEMPERATURE =  300.0 F = 148.9 C               SAMPLING DURATION =  15.00 MIN
IMPACTOR PRESSURE DROP = 1.2 IN. OF HG      STACK TEMPERATURE =  300.0 F = 148.9 C
ASSUMED PARTICLE DENSITY = 1.00 GM/CU.CM.    STACK PRESSURE = 30.00 IN. OF HG     MAX. PARTICLE DIAMETER = 260.3 MICROMETERS
GAS COMPOSITION (PERCENT)           CO2 = 12.88          CO =  0.00            N2 = 73.60          O2 =  5.52           H2O =  8.00
CALC. MASS LOADING = 1.7845E+00 GR/ACF            2.7760E+00 GR/DNCF             4.0836E+03 MG/ACM             6.3525E+03 MG/DNCM
IMPACTOR STAGE                             CYC        S0        S1        S2        S3        S4        S5        S6      FILTER
STAGE INDEX NUMBER                          1          2         3         4         5         6         7         8         9
D50 (MICROMETERS)                         16.79      10.27      5.61      3.55      2.72      1.18      0.87      0.45
MASS (MILLIGRAMS)                         39.38       6.12      2.90      2.16      1.63      1.18      0.30      0.10      0.00
MG/DNCM/STAGE                            4.65E+03  7.23E+02  3.43E+02  2.55E+02  1.93E+02  1.39E+02  3.54E+01  1.18E+01  0.00E-01
CUM. PERCENT OF MASS SMALLER THAN D50    26.76     15.38      9.99      5.97      2.94      0.74      0.19      0.00
CUM. (MG/ACM) SMALLER THAN D50           1.09E+03  6.28E+02  4.08E+02  2.44E+02  1.20E+02  3.04E+01  7.59E+00  0.00E-01
CUM. (MG/DNCM) SMALLER THAN D50          1.70E+03  9.77E+02  6.34E+02  3.79E+02  1.87E+02  4.73E+01  1.18E+01  0.00E-01
CUM. (GR/ACF) SMALLER THAN D50           4.78E-01  2.74E-01  1.78E-01  1.07E-01  5.24E-02  1.33E-02  3.32E-03  0.00E-01
CUM. (GR/DNCF) SMALLER THAN D50          7.43E-01  4.27E-01  2.77E-01  1.66E-01  8.16E-02  2.07E-02  5.16E-03  0.00E-01
GEO. MEAN DIA. (MICROMETERS)             6.61E+01  1.31E+01  7.59E+00  4.46E+00  3.11E+00  1.79E+00  1.01E+00  6.23E-01  3.15E-01
DM/DLOGD (MG/DNCM)                       3.91E+03  3.39E+03  1.31E+03  1.28E+03  1.67E+03  3.83E+02  2.70E+02  4.06E+01  0.00E-01
DN/DLOGD (NO. PARTICLES/DNCM)            2.58E+07  2.86E+09  5.70E+09  2.75E+10  1.06E+11  1.27E+11  4.95E+11  3.20E+11  0.00E-01

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO THE TASK GROUP ON LUNG DYNAMICS.
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HYPOTHETICAL BRINK TEST - CYC, STAGE 0 - STAGE 5, NO FILTER

IMPACTOR FLOWRATE = 0.031 ACFM              IMPACTOR TEMPERATURE =  300.0 F = 148.9 C              SAMPLING DURATION =  15.00 MIN

IMPACTOR PRESSURE DROP = 0.4 IN. OF HG       STACK TEMPERATURE =  300.0 F = 148.9 C

ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.     STACK PRESSURE = 30.00 IN. OF HG     MAX. PARTICLE DIAMETER = 168.0 MICROMETERS

GAS COMPOSITION (PERCENT)          CO2 = 12.88          CO =  0.00          N2 = 73.60          O2 =  5.52          H2O =  8.00

CALC. MASS LOADING = 1.7812E+00 GR/ACF            2.7709E+00 GR/DNCF            4.0760E+03 MG/ACM            6.3407E+03 MG/DNCM

IMPACTOR STAGE                         CYC       S0        S1        S2        S3        S4        S5                  FILTER

STAGE INDEX NUMBER                      1         2         3         4         5         6         7                    8

D50 (MICROMETERS)                    10.84      6.59      3.58      2.25      1.72      0.72      0.53

MASS (MILLIGRAMS)                    39.38      6.12      2.90      2.16      1.63      1.18      0.30                0.00

MG/DSCM/STAGE                      4.65E+03  7.23E+02  3.43E+02  2.55E+02  1.93E+02  1.39E+02  3.54E+01            0.00E-01

CUM. PERCENT OF MASS SMALLER THAN D50  26.63  15.22     9.82      5.79      2.76      0.56      0.00

CUM. (MG/ACM) SMALLER THAN D50     1.09E+03  6.20E+02  4.00E+02  2.36E+02  1.12E+02  2.28E+01  0.00E-01

CUM. (MG/DNCM) SMALLER THAN D50    1.69E+03  9.65E+02  6.23E+02  3.67E+02  1.75E+02  3.54E+01  0.00E-01

CUM. (GR/ACF) SMALLER THAN D50     4.74E-01  2.71E-01  1.75E-01  1.03E-01  4.91E-02  9.96E-03  0.00E-01

CUM. (GR/DNCF) SMALLER THAN D50    7.38E-01  4.22E-01  2.72E-01  1.61E-01  7.64E-02  1.55E-02  0.00E-01

GEO. MEAN DIA. (MICROMETERS)       4.27E+01  8.45E+00  4.86E+00  2.84E+00  1.97E+00  1.12E+00  6.18E-01            1.83E-01

DM/DLOGD (MG/DNCM)                 3.91E+03  3.35E+03  1.30E+03  1.26E+03  1.64E+03  3.71E+02  2.56E+02            0.00E-01

DN/DLOGD (NO. PARTICLES/DNCM)      4.00E+07  4.41E+09  8.98E+09  4.39E+10  1.72E+11  2.13E+11  8.65E+11            0.00E-01


NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
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HYPOTHETICAL BRINK TEST - CYC, STAGE 0 - STAGE 5, NO FILTER
IMPACTOR FLOWRATE = 0,031 ACFM          IMPACTOR TEMPERATURE =  300,0 F = 148,9 C             SAMPLING DURATION =  15,00 MIN
IMPACTOR PRESSURE DROP = 0,4 IN. OF HG      STACK TEMPERATURE =  300,0 F = 148,9 C
ASSUMED PARTICLE DENSITY = 1,00 GM/CU.CM.    STACK PRESSURE = 30,00 IN. OF HG    MAX. PARTICLE DIAMETER = 260,3 MICROMETERS
GAS COMPOSITION (PERCENT)          CO2 = 12,88          CO =  0,00           N2 = 73,60          O2 =  5,52          H2O =  8,00
CALC. MASS LOADING = 1,7812E+00 GR/ACF            2,7709E+00 GR/DNCF             4,0760E+03 MG/ACM             6,3407E+03 MG/DNCM
IMPACTOR STAGE                              CYC        S0         S1         S2         S3         S4         S5                FILTER
STAGE INDEX NUMBER                           1          2          3          4          5          6          7                   8
D50 (MICROMETERS)                         16,79      10,38       5,73       3,66       2,84       1,29       0,98
MASS (MILLIGRAMS)                         39,38       6,12       2,90       2,16       1,63       1,18       0,30                0,00
MG/DSCM/STAGE                          4,65E+03   7,23E+02   3,43E+02   2,55E+02   1,93E+02   1,39E+02   3,54E+01            0,00E-01
CUM. PERCENT OF MASS SMALLER THAN D50   26,63      15,22       9,82       5,79       2,76       0,56       0,00
CUM. (MG/ACM) SMALLER THAN D50         1,09E+03   6,20E+02   4,00E+02   2,36E+02   1,12E+02   2,28E+01   0,00E-01
CUM. (MG/DNCM) SMALLER THAN D50        1,69E+03   9,65E+02   6,23E+02   3,67E+02   1,75E+02   3,54E+01   0,00E-01
CUM. (GR/ACF) SMALLER THAN D50         4,74E-01   2,71E-01   1,75E-01   1,03E-01   4,91E-02   9,96E-03   0,00E-01
CUM. (GR/DNCF) SMALLER THAN D50        7,38E-01   4,22E-01   2,72E-01   1,61E-01   7,64E-02   1,55E-02   0,00E-01
GEO. MEAN DIA. (MICROMETERS)           6,61E+01   1,32E+01   7,71E+00   4,58E+00   3,22E+00   1,91E+00   1,13E+00            3,99E-01
DM/DLOGD (MG/DNCM)                     3,91E+03   3,47E+03   1,33E+03   1,31E+03   1,74E+03   4,07E+02   3,00E+02            0,00E-01
DN/DLOGD (NO. PARTICLES/DNCM)          2,58E+07   2,88E+09   5,52E+09   2,61E+10   9,90E+10   1,11E+11   4,02E+11            0,00E-01

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO MERCER.
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HYPOTHETICAL BRINK TEST - CYC, STAGE 0 - STAGE 5, NO FILTER

IMPACTOR FLOWRATE = 0.031 ACFM              IMPACTOR TEMPERATURE =  300.0 F = 148.9 C           SAMPLING DURATION =  15.00 MIN

IMPACTOR PRESSURE DROP = 0.4 IN. OF HG      STACK TEMPERATURE =  300.0 F = 148.9 C

ASSUMED PARTICLE DENSITY = 1.00 GM/CU.CM.    STACK PRESSURE = 30.00 IN. OF HG    MAX. PARTICLE DIAMETER = 260.3 MICROMETERS

GAS COMPOSITION (PERCENT)          CO2 = 12.88          CO =  0.00          N2 = 73.60          O2 =  5.52          H2O =  8.00

CALC. MASS LOADING = 1.7812E+00 GR/ACF          2.7709E+00 GR/DNCF          4.0760E+03 MG/ACM          6.3407E+03 MG/DNCM

IMPACTOR STAGE                              CYC       S0        S1        S2        S3        S4        S5                  FILTER

STAGE INDEX NUMBER                          1         2         3         4         5         6         7                   8

D50 (MICROMETERS)                           16.79     10.27     5.61      3.55      2.72      1.18      0.87

MASS (MILLIGRAMS)                           39.38     6.12      2.90      2.16      1.63      1.18      0.30                0.00

MG/DSCM/STAGE                               4.65E+03  7.23E+02  3.43E+02  2.55E+02  1.93E+02  1.39E+02  3.54E+01            0.00E-01

CUM. PERCENT OF MASS SMALLER THAN D50       26.63     15.22     9.82      5.79      2.76      0.56      0.00

CUM. (MG/ACM) SMALLER THAN D50              1.09E+03  6.20E+02  4.00E+02  2.36E+02  1.12E+02  2.28E+01  0.00E-01

CUM. (MG/DNCM) SMALLER THAN D50             1.69E+03  9.65E+02  6.23E+02  3.67E+02  1.75E+02  3.54E+01  0.00E-01

CUM. (GR/ACF) SMALLER THAN D50              4.74E-01  2.71E-01  1.75E-01  1.03E-01  4.91E-02  9.96E-03  0.00E-01

CUM. (GR/DNCF) SMALLER THAN D50             7.38E-01  4.22E-01  2.72E-01  1.61E-01  7.64E-02  1.55E-02  0.00E-01

GEO. MEAN DIA. (MICROMETERS)                6.61E+01  1.31E+01  7.59E+00  4.46E+00  3.11E+00  1.79E+00  1.02E+00            3.23E-01

DM/DLOGD (MG/DNCM)                          3.91E+03  3.39E+03  1.31E+03  1.28E+03  1.68E+03  3.84E+02  2.72E+02            0.00E-01

DN/DLOGD (NO. PARTICLES/DNCM)               2.58E+07  2.86E+09  5.70E+09  2.75E+10  1.06E+11  1.27E+11  4.96E+11            0.00E-01


NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.

AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO THE TASK GROUP ON LUNG DYNAMICS.
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HYPOTHETICAL BRINK TEST - STAGE 0 - STAGE 6, FILTER
IMPACTOR FLOWRATE = 0.031 ACFM              IMPACTOR TEMPERATURE =  330.0 F = 165.6 C            SAMPLING DURATION =  15.00 MIN
IMPACTOR PRESSURE DROP = 1.2 IN. OF HG      STACK TEMPERATURE =  330.0 F = 165.6 C
ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.    STACK PRESSURE = 29.50 IN. OF HG    MAX. PARTICLE DIAMETER = 168.0 MICROMETERS
GAS COMPOSITION (PERCENT)          CO2 = 12.88          CO =  0.00          N2 = 73.60          O2 =  5.52          H2O =  8.00
CALC. MASS LOADING = 4.8388E-01 GR/ACF            7.9573E-01 GR/DNCF             1.1073E+03 MG/ACM             1.8209E+03 MG/DNCM
IMPACTOR STAGE                                     S0        S1        S2        S3        S4        S5        S6     FILTER
STAGE INDEX NUMBER                                  1         2         3         4         5         6         7         8
D50 (MICROMETERS)                                6.68      3.63      2.28      1.74      0.73      0.53      0.25
MASS (MILLIGRAMS)                                6.12      2.90      2.16      1.63      1.18      0.30      0.10      0.19
MG/DNCM/STAGE                                7.64E+02  3.62E+02  2.70E+02  2.04E+02  1.47E+02  3.75E+01  1.25E+01  2.37E+01
CUM. PERCENT OF MASS SMALLER THAN D50         58.02     38.13     23.32     12.14      4.05      1.99      1.30
CUM. (MG/ACM) SMALLER THAN D50               6.42E+02  4.22E+02  2.58E+02  1.34E+02  4.48E+01  2.20E+01  1.44E+01
CUM. (MG/DNCM) SMALLER THAN D50              1.06E+03  6.94E+02  4.25E+02  2.21E+02  7.37E+01  3.62E+01  2.37E+01
CUM. (GR/ACF) SMALLER THAN D50               2.81E-01  1.85E-01  1.13E-01  5.87E-02  1.96E-02  9.62E-03  6.31E-03
CUM. (GR/DNCF) SMALLER THAN D50              4.62E-01  3.03E-01  1.86E-01  9.66E-02  3.22E-02  1.58E-02  1.04E-02
GEO. MEAN DIA. (MICROMETERS)                 3.35E+01  4.92E+00  2.88E+00  1.99E+00  1.13E+00  6.20E-01  3.63E-01  1.76E-01
DM/DLOGD (MG/DNCM)                           5.46E+02  1.37E+03  1.33E+03  1.73E+03  3.90E+02  2.67E+02  3.84E+01  7.88E+01
DN/DLOGD (NO. PARTICLES/DNCM)                1.16E+07  9.11E+09  4.46E+10  1.75E+11  2.18E+11  8.91E+11  6.40E+11  1.14E+13

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
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HYPOTHETICAL BRINK TEST - STAGE 0 - STAGE 6, FILTER
IMPACTOR FLOWRATE = 0.031 ACFM               IMPACTOR TEMPERATURE =  330.0 F = 165.6 C             SAMPLING DURATION =  15.00 MIN
IMPACTOR PRESSURE DROP = 1.2 IN. OF HG       STACK TEMPERATURE =  330.0 F = 165.6 C
ASSUMED PARTICLE DENSITY = 1.00 GM/CU.CM.     STACK PRESSURE = 29.50 IN. OF HG     MAX. PARTICLE DIAMETER = 260.3 MICROMETERS
GAS COMPOSITION (PERCENT)          CO2 = 12.88          CO =  0.00           N2 = 73.60          O2 =  5.52            H2O =  8.00
CALC. MASS LOADING = 4.8388E-01 GR/ACF            7.9573E-01 GR/DNCF             1.1073E+03 MG/ACM            1.8209E+03 MG/DNCM
IMPACTOR STAGE                                       S0         S1         S2         S3         S4         S5         S6      FILTER
STAGE INDEX NUMBER                                    1          2          3          4          5          6          7          8
D50 (MICROMETERS)                                  10.54       5.81       3.72       2.88       1.31       1.00       0.57
MASS (MILLIGRAMS)                                   6.12       2.90       2.16       1.63       1.18       0.30       0.10       0.19
MG/DNCM/STAGE                                   7.64E+02   3.62E+02   2.70E+02   2.04E+02   1.47E+02   3.75E+01   1.25E+01   2.37E+01
CUM. PERCENT OF MASS SMALLER THAN D50          58.02      38.13      23.32      12.14       4.05       1.99       1.30
CUM. (MG/ACM) SMALLER THAN D50                  6.42E+02   4.22E+02   2.58E+02   1.34E+02   4.48E+01   2.20E+01   1.44E+01
CUM. (MG/DNCM) SMALLER THAN D50                 1.06E+03   6.94E+02   4.25E+02   2.21E+02   7.37E+01   3.62E+01   2.37E+01
CUM. (GR/ACF) SMALLER THAN D50                  2.81E-01   1.85E-01   1.13E-01   5.87E-02   1.96E-02   9.62E-03   6.31E-03
CUM. (GR/DNCF) SMALLER THAN D50                 4.62E-01   3.03E-01   1.86E-01   9.66E-02   3.22E-02   1.58E-02   1.04E-02
GEO. MEAN DIA. (MICROMETERS)                    5.24E+01   7.83E+00   4.65E+00   3.27E+00   1.94E+00   1.14E+00   7.50E-01   4.00E-01
DM/DLOGD (MG/DNCM)                              5.49E+02   1.40E+03   1.39E+03   1.83E+03   4.30E+02   3.16E+02   5.09E+01   7.88E+01
DN/DLOGD (NO. PARTICLES/DNCM)                   7.30E+06   5.58E+09   2.64E+10   1.00E+11   1.13E+11   4.06E+11   2.30E+11   2.35E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO MERCER.
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HYPOTHETICAL BRINK TEST - STAGE 0 - STAGE 6, FILTER

IMPACTOR FLOWRATE = 0.031 ACFM              IMPACTOR TEMPERATURE =  330.0 F = 165.6 C              SAMPLING DURATION =  15.00 MIN

IMPACTOR PRESSURE DROP = 1.2 IN. OF HG      STACK TEMPERATURE =  330.0 F = 165.6 C

ASSUMED PARTICLE DENSITY = 1.00 GM/CU.CM.     STACK PRESSURE = 29.50 IN. OF HG     MAX. PARTICLE DIAMETER = 260.3 MICROMETERS

GAS COMPOSITION (PERCENT)          CO2 = 12.88          CO =  0.00           N2 = 73.60           O2 =  5.52           H2O =  8.00

CALC. MASS LOADING = 4.8388E-01 GR/ACF              7.9573E-01 GR/DNCF              1.1073E+03 MG/ACM              1.8209E+03 MG/DNCM

IMPACTOR STAGE                                      S0        S1        S2        S3        S4        S5        S6      FILTER

STAGE INDEX NUMBER                                   1         2         3         4         5         6         7         8

D50 (MICROMETERS)                                  10.42      5.69      3.60      2.76      1.19      0.88      0.45

MASS (MILLIGRAMS)                                   6.12      2.90      2.16      1.63      1.18      0.30      0.10      0.19

MG/DNCM/STAGE                                     7.64E+02  3.62E+02  2.70E+02  2.04E+02  1.47E+02  3.75E+01  1.25E+01  2.37E+01

CUM. PERCENT OF MASS SMALLER THAN D50            58.02     38.13     23.32     12.14      4.05      1.99      1.30

CUM. (MG/ACM) SMALLER THAN D50                    6.42E+02  4.22E+02  2.58E+02  1.34E+02  4.48E+01  2.20E+01  1.44E+01

CUM. (MG/DNCM) SMALLER THAN D50                   1.06E+03  6.94E+02  4.25E+02  2.21E+02  7.37E+01  3.62E+01  2.37E+01

CUM. (GR/ACF) SMALLER THAN D50                    2.81E-01  1.85E-01  1.13E-01  5.87E-02  1.96E-02  9.62E-03  6.31E-03

CUM. (GR/DNCF) SMALLER THAN D50                   4.62E-01  3.03E-01  1.86E-01  9.66E-02  3.22E-02  1.58E-02  1.04E-02

GEO. MEAN DIA. (MICROMETERS)                      5.21E+01  7.70E+00  4.52E+00  3.15E+00  1.81E+00  1.02E+00  6.27E-01  3.16E-01

DM/DLOGD (MG/DNCM)                                5.47E+02  1.38E+03  1.35E+03  1.77E+03  4.04E+02  2.84E+02  4.26E+01  7.88E+01

DN/DLOGD (NO. PARTICLES/DNCM)                     7.40E+06  5.77E+09  2.79E+10  1.08E+11  1.30E+11  5.07E+11  3.30E+11  4.75E+12


NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.

AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO THE TASK GROUP ON LUNG DYNAMICS.
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HYPOTHETICAL BRINK TEST - STAGE 0 - STAGE 5, FILTER
IMPACTOR FLOWRATE = 0.031 ACFM            IMPACTOR TEMPERATURE =  300.0 F = 148.9 C            SAMPLING DURATION =  15.00 MIN
IMPACTOR PRESSURE DROP = 0.4 IN. OF HG    STACK TEMPERATURE =  300.0 F = 148.9 C
ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.   STACK PRESSURE = 30.00 IN. OF HG    MAX. PARTICLE DIAMETER = 168.0 MICROMETERS
GAS COMPOSITION (PERCENT)          CO2 = 12.88        CO =  0.00          N2 = 73.60          O2 =  5.52          H2O =  8.00
CALC. MASS LOADING = 4.8056E-01 GR/ACF         7.4757E-01 GR/DNCF          1.0997E+03 MG/ACM             1.7107E+03 MG/DNCM
IMPACTOR STAGE                                  S0        S1        S2        S3        S4        S5              FILTER
STAGE INDEX NUMBER                              1         2         3         4         5         6                 7
D50 (MICROMETERS)                             6.59      3.58      2.25      1.72      0.72      0.53
MASS (MILLIGRAMS)                             6.12      2.90      2.16      1.63      1.18      0.30              0.19
MG/DNCM/STAGE                               7.23E+02  3.43E+02  2.55E+02  1.93E+02  1.39E+02  3.54E+01          2.24E+01
CUM. PERCENT OF MASS SMALLER THAN D50      57.73     37.71     22.79     11.53      3.38      1.31
CUM. (MG/ACM) SMALLER THAN D50              6.35E+02  4.15E+02  2.51E+02  1.27E+02  3.72E+01  1.44E+01
CUM. (MG/DNCM) SMALLER THAN D50             9.88E+02  6.45E+02  3.90E+02  1.97E+02  5.79E+01  2.24E+01
CUM. (GR/ACF) SMALLER THAN D50              2.77E-01  1.81E-01  1.10E-01  5.54E-02  1.63E-02  6.31E-03
CUM. (GR/DNCF) SMALLER THAN D50             4.32E-01  2.82E-01  1.70E-01  8.62E-02  2.53E-02  9.81E-03
GEO. MEAN DIA. (MICROMETERS)                3.33E+01  4.86E+00  2.84E+00  1.97E+00  1.12E+00  6.18E-01          3.73E-01
DM/DLOGD (MG/DNCM)                          5.14E+02  1.30E+03  1.26E+03  1.64E+03  3.71E+02  2.56E+02          7.46E+01
DN/DLOGD (NO. PARTICLES/DNCM)               1.11E+07  8.98E+09  4.39E+10  1.72E+11  2.13E+11  8.65E+11          1.15E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
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HYPOTHETICAL BRINK TEST - STAGE 0 - STAGE 5, FILTER
IMPACTOR FLOWRATE = 0.031 ACFM              IMPACTOR TEMPERATURE =  300.0 F = 148.9 C              SAMPLING DURATION =  15.00 MIN
IMPACTOR PRESSURE DROP = 0.4 IN. OF HG      STACK TEMPERATURE =  300.0 F = 148.9 C
ASSUMED PARTICLE DENSITY = 1.00 GM/CU.CM.    STACK PRESSURE = 30.00 IN. OF HG     MAX. PARTICLE DIAMETER = 260.3 MICROMETERS
GAS COMPOSITION (PERCENT)          CO2 = 12.88          CO =  0.00          N2 = 73.60          O2 =  5.52          H2O =  8.00
CALC. MASS LOADING = 4.8056E-01 GR/ACF             7.4757E-01 GR/DNCF             1.0997E+03 MG/ACM             1.7107E+03 MG/DNCM
IMPACTOR STAGE                                 S0        S1        S2        S3        S4        S5                 FILTER
STAGE INDEX NUMBER                              1         2         3         4         5         6                    7
D50 (MICROMETERS)                            10.38      5.73      3.66      2.84      1.29      0.98
MASS (MILLIGRAMS)                             6.12      2.90      2.16      1.63      1.18      0.30                 0.19
MG/DNCM/STAGE                             7.23E+02  3.43E+02  2.55E+02  1.93E+02  1.39E+02  3.54E+01             2.24E+01
CUM. PERCENT OF MASS SMALLER THAN D50       57.73     37.71     22.79     11.53      3.38      1.31
CUM. (MG/ACM) SMALLER THAN D50            6.35E+02  4.15E+02  2.51E+02  1.27E+02  3.72E+01  1.44E+01
CUM. (MG/DNCM) SMALLER THAN D50           9.88E+02  6.45E+02  3.90E+02  1.97E+02  5.79E+01  2.24E+01
CUM. (GR/ACF) SMALLER THAN D50            2.77E-01  1.81E-01  1.10E-01  5.54E-02  1.63E-02  6.31E-03
CUM. (GR/DNCF) SMALLER THAN D50           4.32E-01  2.82E-01  1.70E-01  8.62E-02  2.53E-02  9.81E-03
GEO. MEAN DIA. (MICROMETERS)              5.20E+01  7.71E+00  4.58E+00  3.22E+00  1.91E+00  1.13E+00             6.95E-01
DM/DLOGD (MG/DNCM)                        5.17E+02  1.33E+03  1.31E+03  1.74E+03  4.07E+02  3.00E+02             7.46E+01
DN/DLOGD (NO. PARTICLES/DNCM)             7.03E+06  5.52E+09  2.61E+10  9.90E+10  1.11E+11  4.02E+11             4.25E+11

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO MERCER.
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HYPOTHETICAL BRINK TEST - STAGE 0 - STAGE 5, FILTER

IMPACTOR FLOWRATE = 0,031 ACFM              IMPACTOR TEMPERATURE =  300,0 F = 148,9 C            SAMPLING DURATION =  15,00 MIN

IMPACTOR PRESSURE DROP = 0,4 IN, OF HG      STACK TEMPERATURE =  300,0 F = 148,9 C

ASSUMED PARTICLE DENSITY = 1,00 GM/CU,CM,     STACK PRESSURE = 30,00 IN, OF HG     MAX, PARTICLE DIAMETER = 260,3 MICROMETERS

GAS COMPOSITION (PERCENT)          CO2 = 12,88          CO =  0,00            N2 = 73,60          O2 =  5,52           H2O =  8,00

CALC, MASS LOADING = 4,8056E-01 GR/ACF             7,4757E-01 GR/DNCF              1,0997E+03 MG/ACM              1,7107E+03 MG/DNCM

IMPACTOR STAGE                                   S0        S1        S2        S3        S4        S5                FILTER

STAGE INDEX NUMBER                               1         2         3         4         5         6                   7

D50 (MICROMETERS)                              10,27      5,61      3,55      2,72      1,18      0,87

MASS (MILLIGRAMS)                               6,12      2,90      2,16      1,63      1,18      0,30                0,19

MG/DNCM/STAGE                                7,23E+02  3,43E+02  2,55E+02  1,93E+02  1,39E+02  3,54E+01            2,24E+01

CUM, PERCENT OF MASS SMALLER THAN D50         57,73     37,71     22,79     11,53      3,38      1,31

CUM, (MG/ACM) SMALLER THAN D50               6,35E+02  4,15E+02  2,51E+02  1,27E+02  3,72E+01  1,44E+01

CUM, (MG/DNCM) SMALLER THAN D50              9,88E+02  6,45E+02  3,90E+02  1,97E+02  5,79E+01  2,24E+01

CUM, (GR/ACF) SMALLER THAN D50               2,77E-01  1,81E-01  1,10E-01  5,54E-02  1,63E-02  6,31E-03

CUM, (GR/DNCF) SMALLER THAN D50              4,32E-01  2,82E-01  1,70E-01  8,62E-02  2,53E-02  9,81E-03

GEO, MEAN DIA, (MICROMETERS)                 5,17E+01  7,59E+00  4,46E+00  3,11E+00  1,79E+00  1,02E+00            6,18E-01

DM/DLOGD (MG/DNCM)                           5,15E+02  1,31E+03  1,28E+03  1,68E+03  3,84E+02  2,72E+02            7,46E+01

DN/DLOGD (NO, PARTICLES/DNCM)                7,12E+06  5,70E+09  2,75E+10  1,06E+11  1,27E+11  4,96E+11            6,04E+11


NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.

AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO THE TASK GROUP ON LUNG DYNAMICS.
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HYPOTHETICAL BRINK TEST - STAGE 0 - STAGE 6, NO FILTER
IMPACTOR FLOWRATE = 0.031 ACFM              IMPACTOR TEMPERATURE =  300.0 F = 148.9 C                 SAMPLING DURATION =  15.00 MIN
IMPACTOR PRESSURE DROP = 1.2 IN. OF HG      STACK TEMPERATURE =  300.0 F = 148.9 C
ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.    STACK PRESSURE = 30.00 IN. OF HG     MAX. PARTICLE DIAMETER = 168.0 MICROMETERS
GAS COMPOSITION (PERCENT)          CO2 = 12.88          CO =  0.00             N2 = 73.60           O2 =  5.52           H2O =  8.00
CALC. MASS LOADING = 4.7757E-01 GR/ACF             7.4292E-01 GR/DNCF              1.0929E+03 MG/ACM              1.7001E+03 MG/DNCM
IMPACTOR STAGE                                     S0        S1        S2        S3        S4        S5        S6     FILTER
STAGE INDEX NUMBER                                 1         2         3         4         5         6         7         8
D50 (MICROMETERS)                                 6.59      3.58      2.25      1.72      0.72      0.53      0.25
MASS (MILLIGRAMS)                                 6.12      2.90      2.16      1.63      1.18      0.30      0.10      0.00
MG/DNCM/STAGE                                   7.23E+02  3.43E+02  2.55E+02  1.93E+02  1.39E+02  3.54E+01  1.18E+01  0.00E-01
CUM. PERCENT OF MASS SMALLER THAN D50         57.47     37.32     22.31     10.98      2.78      0.69      0.00
CUM. (MG/ACM) SMALLER THAN D50                  6.28E+02  4.08E+02  2.44E+02  1.20E+02  3.04E+01  7.59E+00  0.00E-01
CUM. (MG/DNCM) SMALLER THAN D50                 9.77E+02  6.34E+02  3.79E+02  1.87E+02  4.73E+01  1.18E+01  0.00E-01
CUM. (GR/ACF) SMALLER THAN D50                  2.74E-01  1.78E-01  1.07E-01  5.24E-02  1.33E-02  3.32E-03  0.00E-01
CUM. (GR/DNCF) SMALLER THAN D50                 4.27E-01  2.77E-01  1.66E-01  8.16E-02  2.07E-02  5.16E-03  0.00E-01
GEO. MEAN DIA. (MICROMETERS)                    3.33E+01  4.86E+00  2.84E+00  1.97E+00  1.12E+00  6.17E-01  3.63E-01  1.77E-01
DM/DLOGD (MG/DNCM)                              5.14E+02  1.30E+03  1.26E+03  1.64E+03  3.71E+02  2.55E+02  3.68E+01  0.00E-01
DN/DLOGD (NO. PARTICLES/DNCM)                   1.11E+07  8.98E+09  4.39E+10  1.72E+11  2.13E+11  8.65E+11  6.12E+11  0.00E-01

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
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HYPOTHETICAL BRINK TEST - STAGE 0 - STAGE 6, NO FILTER
IMPACTOR FLOWRATE = 0.031 ACFM              IMPACTOR TEMPERATURE =  300.0 F = 148.9 C              SAMPLING DURATION =  15.00 MIN
IMPACTOR PRESSURE DROP = 1.2 IN. OF HG      STACK TEMPERATURE =  300.0 F = 148.9 C
ASSUMED PARTICLE DENSITY = 1.00 GM/CU.CM.    STACK PRESSURE = 30.00 IN. OF HG     MAX. PARTICLE DIAMETER = 260.3 MICROMETERS
GAS COMPOSITION (PERCENT)          CO2 = 12.88          CO =  0.00           N2 = 73.60           O2 =  5.52           H2O =  8.00
CALC. MASS LOADING = 4.7757E-01 GR/ACF              7.4292E-01 GR/DNCF               1.0929E+03 MG/ACM               1.7001E+03 MG/DNCM
IMPACTOR STAGE                                  S0        S1        S2        S3        S4        S5        S6      FILTER
STAGE INDEX NUMBER                              1         2         3         4         5         6         7         8
D50 (MICROMETERS)                             10.38      5.73      3.66      2.84      1.29      0.98      0.56
MASS (MILLIGRAMS)                              6.12      2.90      2.16      1.63      1.18      0.30      0.10      0.00
MG/DNCM/STAGE                                7.23E+02  3.03E+02  2.55E+02  1.93E+02  1.39E+02  3.54E+01  1.18E+01  0.00E-01
CUM. PERCENT OF MASS SMALLER THAN D50       57.47     37.32     22.31     10.98      2.78      0.69      0.00
CUM. (MG/ACM) SMALLER THAN D50               6.28E+02  4.08E+02  2.44E+02  1.20E+02  3.04E+01  7.59E+00  0.00E-01
CUM. (MG/DNCM) SMALLER THAN D50              9.77E+02  6.34E+02  3.79E+02  1.87E+02  4.73E+01  1.18E+01  0.00E-01
CUM. (GR/ACF) SMALLER THAN D50               2.74E-01  1.78E-01  1.07E-01  5.24E-02  1.33E-02  3.32E-03  0.00E-01
CUM. (GR/DNCF) SMALLER THAN D50              4.27E-01  2.77E-01  1.66E-01  8.16E-02  2.07E-02  5.16E-03  0.00E-01
GEO. MEAN DIA. (MICROMETERS)                 5.20E+01  7.71E+00  4.58E+00  3.22E+00  1.91E+00  1.12E+00  7.39E-01  3.94E-01
DM/DLOGD (MG/DNCM)                           5.17E+02  1.33E+03  1.31E+03  1.73E+03  4.07E+02  2.99E+02  4.81E+01  0.00E-01
DN/DLOGD (NO. PARTICLES/DNCM)                7.03E+06  5.52E+09  2.61E+10  9.90E+10  1.11E+11  4.01E+11  2.28E+11  0.00E-01

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO MERCER.
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HYPOTHETICAL BRINK TEST - STAGE 0 - STAGE 6, NO FILTER

IMPACTOR FLOWRATE = 0,031 ACFM              IMPACTOR TEMPERATURE =  300,0 F = 148,9 C           SAMPLING DURATION =  15,00 MIN

IMPACTOR PRESSURE DROP = 1,2 IN, OF HG      STACK TEMPERATURE =  300,0 F = 148,9 C

ASSUMED PARTICLE DENSITY = 1,00 GM/CU,CM,    STACK PRESSURE = 30,00 IN, OF HG     MAX, PARTICLE DIAMETER = 260,3 MICROMETERS

GAS COMPOSITION (PERCENT)          CO2 = 12,88          CO =  0,00          N2 = 73,60          O2 =  5,52          H2O =  8,00

CALC, MASS LOADING = 4,7757E-01 GR/ACF              7,4292E-01 GR/DNCF              1,0929E+03 MG/ACM              1,7001E+03 MG/DNCM

IMPACTOR STAGE                                S0        S1        S2        S3        S4        S5        S6     FILTER

STAGE INDEX NUMBER                             1         2         3         4         5         6         7         8

D50 (MICROMETERS)                           10,27      5,61      3,55      2,72      1,18      0,87      0,45

MASS (MILLIGRAMS)                            6,12      2,90      2,16      1,63      1,18      0,30      0,10      0,00

MG/DNCM/STAGE                             7,23E+02  3,43E+02  2,55E+02  1,93E+02  1,39E+02  3,54E+01  1,18E+01  0,00E-01

CUM, PERCENT OF MASS SMALLER THAN D50      57,47     37.32     22.31     10,98      2.78      0,69      0,00

CUM, (MG/ACM) SMALLER THAN D50            6,28E+02  4,08E+02  2,44E+02  1,20E+02  3,04E+01  7,59E+00  0,00E-01

CUM, (MG/DNCM) SMALLER THAN D50           9,77E+02  6,34E+02  3,79E+02  1,87E+02  4,73E+01  1,18E+01  0,00E-01

CUM, (GR/ACF) SMALLER THAN D50            2,74E-01  1,78E-01  1,07E-01  5,24E-02  1,33E-02  3,32E-03  0,00E-01

CUM, (GR/DNCF) SMALLER THAN D50           4,27E-01  2,77E-01  1,66E-01  8,16E-02  2,07E-02  5,16E-03  0,00E-01

GEO, MEAN DIA, (MICROMETERS)              5,17E+01  7,59E+00  4,46E+00  3,11E+00  1,79E+00  1,01E+00  6,23E-01  3,15E-01

DM/DLOGD (MG/DNCM)                        5,15E+02  1,31E+03  1,28E+03  1,67E+03  3,83E+02  2,70E+02  4,06E+01  0,00E-01

DN/DLOGD (NO, PARTICLES/DNCM)             7,12E+06  5,70E+09  2,75E+10  1,06E+11  1,27E+11  4,95E+11  3,20E+11  0,00E-01


NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO THE TASK GROUP ON LUNG DYNAMICS,
HYPOTHETICAL BRINK TEST - STAGE 0 - STAGE 5, NO FILTER
IMPACTOR FLOWRATE = 0,031 ACFM              IMPACTOR TEMPERATURE =  300,0 F = 148,9 C              SAMPLING DURATION =  15,00 MIN
IMPACTOR PRESSURE DROP = 0,4 IN, OF HG      STACK TEMPERATURE =  300,0 F = 148,9 C
ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM,    STACK PRESSURE = 30,00 IN, OF HG     MAX, PARTICLE DIAMETER = 168,0 MICROMETERS
GAS COMPOSITION (PERCENT)          CO2 = 12,88        CO =  0,00          N2 = 73,60          O2 =  5,52          H2O =  8,00
CALC, MASS LOADING = 4,7426E-01 GR/ACF            7,3776E-01 GR/DNCF           1,0853E+03 MG/ACM             1,6882E+03 MG/DNCM
IMPACTOR STAGE                                 S0        S1        S2        S3        S4        S5               FILTER
STAGE INDEX NUMBER                              1         2         3         4         5         6                  7
D50 (MICROMETERS)                            6,59      3,58      2,25      1,72      0,72      0,53
MASS (MILLIGRAMS)                            6,12      2,90      2,16      1,63      1,18      0,30               0,00
MG/DNCM/STAGE                            7,23E+02  3,43E+02  2,55E+02  1,93E+02  1,39E+02  3,54E+01           0,00E-01
CUM, PERCENT OF MASS SMALLER THAN D50   57,17     36,88     21,76     10,36      2,10      0,00
CUM, (MG/ACM) SMALLER THAN D50           6,20E+02  4,00E+02  2,36E+02  1,12E+02  2,28E+01  0,00E-01
CUM, (MG/DNCM) SMALLER THAN D50          9,65E+02  6,23E+02  3,67E+02  1,75E+02  3,54E+01  0,00E-01
CUM, (GR/ACF) SMALLER THAN D50           2,71E-01  1,75E-01  1,03E-01  4,91E-02  9,96E-03  0,00E-01
CUM, (GR/DNCF) SMALLER THAN D50          4,22E-01  2,72E-01  1,61E-01  7,64E-02  1,55E-02  0,00E-01
GEO, MEAN DIA, (MICROMETERS)             3,33E+01  4,86E+00  2,84E+00  1,97E+00  1,12E+00  6,18E-01           3,73E-01
DM/DLOGD (MG/DNCM)                       5,14E+02  1,30E+03  1,26E+03  1,64E+03  3,71E+02  2,56E+02           0,00E-01
DN/DLOGD (NO, PARTICLES/DNCM)            1,11E+07  8,98E+09  4,39E+10  1,72E+11  2,13E+11  8,65E+11           0,00E-01

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,
HYPOTHETICAL BRINK TEST - STAGE 0 - STAGE 5, NO FILTER
IMPACTOR FLOWRATE = 0.031 ACFM                IMPACTOR TEMPERATURE =  300.0 F = 148.9 C              SAMPLING DURATION =  15.00 MIN
IMPACTOR PRESSURE DROP = 0.4 IN. OF HG        STACK TEMPERATURE =  300.0 F = 148.9 C
ASSUMED PARTICLE DENSITY = 1.00 GM/CU.CM.      STACK PRESSURE = 30.00 IN. OF HG      MAX. PARTICLE DIAMETER = 260.3 MICROMETERS
GAS COMPOSITION (PERCENT)           CO2 = 12.88           CO =  0.00           N2 = 73.60           O2 =  5.52           H2O =  8.00
CALC. MASS LOADING = 4.7426E-01 GR/ACF              7.3776E-01 GR/DNCF              1.0853E+03 MG/ACM              1.6882E+03 MG/DNCM
IMPACTOR STAGE                                    S0         S1         S2         S3         S4         S5                  FILTER
STAGE INDEX NUMBER                                1          2          3          4          5          6                   7
D50 (MICROMETERS)                               10.38       5.73       3.66       2.84       1.29       0.98
MASS (MILLIGRAMS)                                6.12       2.90       2.16       1.63       1.18       0.30                0.00
MG/DNCM/STAGE                                   7.23E+02   3.43E+02   2.55E+02   1.93E+02   1.39E+02   3.54E+01            0.00E-01
CUM. PERCENT OF MASS SMALLER THAN D50          57.17      36.88      21.76      10.36       2.10       0.00
CUM. (MG/ACM) SMALLER THAN D50                  6.20E+02   4.00E+02   2.36E+02   1.12E+02   2.28E+01   0.00E-01
CUM. (MG/DNCM) SMALLER THAN D50                 9.65E+02   6.23E+02   3.67E+02   1.75E+02   3.54E+01   0.00E-01
CUM. (GR/ACF) SMALLER THAN D50                  2.71E-01   1.75E-01   1.03E-01   4.91E-02   9.96E-03   0.00E-01
CUM. (GR/DNCF) SMALLER THAN D50                 4.22E-01   2.72E-01   1.61E-01   7.64E-02   1.55E-02   0.00E-01
GEO. MEAN DIA. (MICROMETERS)                    5.20E+01   7.71E+00   4.58E+00   3.22E+00   1.91E+00   1.13E+00            6.95E-01
DM/DLOGD (MG/DNCM)                              5.17E+02   1.33E+03   1.31E+03   1.74E+03   4.07E+02   3.00E+02            0.00E-01
DN/DLOGD (NO. PARTICLES/DNCM)                   7.03E+06   5.52E+09   2.61E+10   9.90E+10   1.11E+11   4.02E+11            0.00E-01

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO MERCER.
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HYPOTHETICAL BRINK TEST - STAGE 0 - STAGE 5, NO FILTER
IMPACTOR FLOWRATE = 0.031 ACFM              IMPACTOR TEMPERATURE =  300.0 F = 148.9 C            SAMPLING DURATION =  15.00 MIN
IMPACTOR PRESSURE DROP = 0.4 IN. OF HG      STACK TEMPERATURE =  300.0 F = 148.9 C
ASSUMED PARTICLE DENSITY = 1.00 GM/CU.CM.    STACK PRESSURE = 30.00 IN. OF HG    MAX. PARTICLE DIAMETER = 260.3 MICROMETERS
GAS COMPOSITION (PERCENT)          CO2 = 12.88          CO =  0.00          N2 = 73.60          O2 =  5.52          H2O =  8.00
CALC. MASS LOADING = 4.7426E-01 GR/ACF                 7.3776E-01 GR/DNCF          1.0853E+03 MG/ACM          1.6882E+03 MG/DNCM
IMPACTOR STAGE                                    S0         S1         S2         S3         S4         S5                FILTER
STAGE INDEX NUMBER                                 1          2          3          4          5          6                   7
D50 (MICROMETERS)                              10.27       5.61       3.55       2.72       1.18       0.87
MASS (MILLIGRAMS)                               6.12       2.90       2.16       1.63       1.18       0.30                0.00
MG/DNCM/STAGE                               7.23E+02   3.43E+02   2.55E+02   1.93E+02   1.39E+02   3.54E+01            0.00E-01
CUM. PERCENT OF MASS SMALLER THAN D50      57.17      36.88      21.76      10.36       2.10       0.00
CUM. (MG/ACM) SMALLER THAN D50              6.20E+02   4.00E+02   2.36E+02   1.12E+02   2.28E+01   0.00E-01
CUM. (MG/DNCM) SMALLER THAN D50             9.65E+02   6.23E+02   3.67E+02   1.75E+02   3.54E+01   0.00E-01
CUM. (GR/ACF) SMALLER THAN D50              2.71E-01   1.75E-01   1.03E-01   4.91E-02   9.96E-03   0.00E-01
CUM. (GR/DNCF) SMALLER THAN D50             4.22E-01   2.72E-01   1.61E-01   7.64E-02   1.55E-02   0.00E-01
GEO. MEAN DIA. (MICROMETERS)                5.17E+01   7.59E+00   4.46E+00   3.11E+00   1.79E+00   1.02E+00            6.18E-01
DM/DLOGD (MG/DNCM)                          5.15E+02   1.31E+03   1.28E+03   1.68E+03   3.84E+02   2.72E+02            0.00E-01
DN/DLOGD (NO. PARTICLES/DNCM)               7.12E+06   5.70E+09   2.75E+10   1.06E+11   1.27E+11   4.96E+11            0.00E-01

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO THE TASK GROUP ON LUNG DYNAMICS.
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HYPOTHETICAL BRINK TEST - STAGE 1 - STAGE 6, FILTER
IMPACTOR FLOWRATE = 0.031 ACFM              IMPACTOR TEMPERATURE =  330.0 F = 165.6 C           SAMPLING DURATION =  15.00 MIN
IMPACTOR PRESSURE DROP = 1.2 IN. OF HG      STACK TEMPERATURE =  330.0 F = 165.6 C
ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.    STACK PRESSURE = 29.50 IN. OF HG    MAX. PARTICLE DIAMETER = 168.0 MICROMETERS
GAS COMPOSITION (PERCENT)         CO2 = 12.88         CO =  0.00          N2 = 73.60          O2 =  5.52          H2O =  8.00
CALC. MASS LOADING = 2.8077E-01 GR/ACF             4.6172E-01 GR/DNCF            6.4250E+02 MG/ACM            1.0566E+03 MG/DNCM
IMPACTOR STAGE                                   S1        S2        S3        S4        S5        S6      FILTER
STAGE INDEX NUMBER                                1         2         3         4         5         6         7
D50 (MICROMETERS)                              3.63      2.28      1.74      0.73      0.53      0.25
MASS (MILLIGRAMS)                              2.90      2.16      1.63      1.18      0.30      0.10      0.19
MG/DNCM/STAGE                               3.62E+02  2.70E+02  2.04E+02  1.47E+02  3.75E+01  1.25E+01  2.37E+01
CUM. PERCENT OF MASS SMALLER THAN D50         65.72     40.19     20.92      6.97      3.43      2.25
CUM. (MG/ACM) SMALLER THAN D50              4.22E+02  2.58E+02  1.34E+02  4.48E+01  2.20E+01  1.44E+01
CUM. (MG/DNCM) SMALLER THAN D50             6.94E+02  4.25E+02  2.21E+02  7.37E+01  3.62E+01  2.37E+01
CUM. (GR/ACF) SMALLER THAN D50              1.85E-01  1.13E-01  5.87E-02  1.96E-02  9.62E-03  6.31E-03
CUM. (GR/DNCF) SMALLER THAN D50             3.03E-01  1.86E-01  9.66E-02  3.22E-02  1.58E-02  1.04E-02
GEO. MEAN DIA. (MICROMETERS)                2.47E+01  2.88E+00  1.99E+00  1.13E+00  6.20E-01  3.63E-01  3.73E-01
DM/DLOGD (MG/DNCM)                          2.17E+02  1.33E+03  1.73E+03  3.90E+02  2.67E+02  3.84E+01  7.88E+01
DN/DLOGD (NO. PARTICLES/DNCM)               1.15E+07  4.46E+10  1.75E+11  2.18E+11  8.91E+11  6.40E+11  1.21E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
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HYPOTHETICAL BRINK TEST - STAGE 1 - STAGE 6, FILTER
IMPACTOR FLOWRATE = 0.031 ACFM          IMPACTOR TEMPERATURE =  330.0 F = 165.6 C          SAMPLING DURATION =  15.00 MIN
IMPACTOR PRESSURE DROP = 1.2 IN. OF HG     STACK TEMPERATURE =  330.0 F = 165.6 C
ASSUMED PARTICLE DENSITY = 1.00 GM/CU.CM.    STACK PRESSURE = 29.50 IN. OF HG    MAX. PARTICLE DIAMETER = 260.3 MICROMETERS
GAS COMPOSITION (PERCENT)         CO2 = 12.88         CO =  0.00          N2 = 73.60          O2 =  5.52          H2O =  8.00
CALC. MASS LOADING = 2.8077E-01 GR/ACF            4.6172E-01 GR/DNCF             6.4250E+02 MG/ACM              1.0566E+03 MG/DNCM
IMPACTOR STAGE                                        S1        S2        S3        S4        S5        S6      FILTER
STAGE INDEX NUMBER                                    1         2         3         4         5         6         7
D50 (MICROMETERS)                                  5.81      3.72      2.88      1.31      1.00      0.57
MASS (MILLIGRAMS)                                  2.90      2.16      1.63      1.18      0.30      0.10      0.19
MG/DNCM/STAGE                                    3.62E+02  2.70E+02  2.04E+02  1.47E+02  3.75E+01  1.25E+01  2.37E+01
CUM. PERCENT OF MASS SMALLER THAN D50            65.72     40.19     20.92      6.97      3.43      2.25
CUM. (MG/ACM) SMALLER THAN D50                   4.22E+02  2.58E+02  1.34E+02  4.48E+01  2.20E+01  1.44E+01
CUM. (MG/DNCM) SMALLER THAN D50                  6.94E+02  4.25E+02  2.21E+02  7.37E+01  3.62E+01  2.37E+01
CUM. (GR/ACF) SMALLER THAN D50                   1.85E-01  1.13E-01  5.87E-02  1.96E-02  9.62E-03  6.31E-03
CUM. (GR/DNCF) SMALLER THAN D50                  3.03E-01  1.86E-01  9.66E-02  3.22E-02  1.58E-02  1.04E-02
GEO. MEAN DIA. (MICROMETERS)                     3.89E+01  4.65E+00  3.27E+00  1.94E+00  1.14E+00  7.50E-01  7.04E-01
DM/DLOGD (MG/DNCM)                               2.19E+02  1.39E+03  1.83E+03  4.30E+02  3.16E+02  5.09E+01  7.88E+01
DN/DLOGD (NO. PARTICLES/DNCM)                    7.12E+06  2.64E+10  1.00E+11  1.13E+11  4.06E+11  2.30E+11  4.32E+11

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO MERCER.
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HYPOTHETICAL BRINK TEST - STAGE 1 - STAGE 6, FILTER
IMPACTOR FLOWRATE = 0,031 ACFM            IMPACTOR TEMPERATURE =  330,0 F = 165,6 C            SAMPLING DURATION =  15,00 MIN
IMPACTOR PRESSURE DROP = 1,2 IN, OF HG     STACK TEMPERATURE =  330,0 F = 165,6 C
ASSUMED PARTICLE DENSITY = 1,00 GM/CU,CM,    STACK PRESSURE = 29,50 IN, OF HG     MAX, PARTICLE DIAMETER = 260,3 MICROMETERS
GAS COMPOSITION (PERCENT)          CO2 = 12,88          CO =  0,00            N2 = 73,60          O2 =  5,52          H2O =  8,00
CALC, MASS LOADING = 2,8077E-01 GR/ACF          4,6172E-01 GR/DNCF            6,4250E+02 MG/ACM            1,0566E+03 MG/DNCM
IMPACTOR STAGE                                      S1         S2         S3         S4         S5         S6        FILTER
STAGE INDEX NUMBER                                   1          2          3          4          5          6          7
D50 (MICROMETERS)                                 5,69       3,60       2,76       1,19       0,88       0,45
MASS (MILLIGRAMS)                                 2,90       2,16       1,63       1,18       0,30       0,10       0,19
MG/DNCM/STAGE                                 3,62E+02   2,70E+02   2,04E+02   1,47E+02   3,75E+01   1,25E+01   2,37E+01
CUM, PERCENT OF MASS SMALLER THAN D50            65,72      40,19      20,92       6,97       3,43       2,25
CUM, (MG/ACM) SMALLER THAN D50                4,22E+02   2,58E+02   1,34E+02   4,48E+01   2,20E+01   1,44E+01
CUM, (MG/DNCM) SMALLER THAN D50               6,94E+02   4,25E+02   2,21E+02   7,37E+01   3,62E+01   2,37E+01
CUM, (GR/ACF) SMALLER THAN D50                1,85E-01   1,13E-01   5,87E-02   1,96E-02   9,62E-03   6,31E-03
CUM, (GR/DNCF) SMALLER THAN D50               3,03E-01   1,86E-01   9,66E-02   3,22E-02   1,58E-02   1,04E-02
GEO, MEAN DIA, (MICROMETERS)                  3,85E+01   4,52E+00   3,15E+00   1,81E+00   1,02E+00   6,27E-01   6,21E-01
DM/DLOGD (MG/DNCM)                            2,18E+02   1,35E+03   1,77E+03   4,04E+02   2,84E+02   4,26E+01   7,86E+01
DN/DLOGD (NO, PARTICLES/DNCM)                 7,31E+06   2,79E+10   1,08E+11   1,30E+11   5,07E+11   3,30E+11   6,27E+11

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,
AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO THE TASK GROUP ON LUNG DYNAMICS,
HYPOTHETICAL BRINK TEST - STAGE 1 - STAGE 5, FILTER
IMPACTOR FLOWRATE = 0.031 ACFM            IMPACTOR TEMPERATURE =  300.0 F = 148.9 C            SAMPLING DURATION =  15.00 MIN
IMPACTOR PRESSURE DROP = 0.4 IN. OF HG    STACK TEMPERATURE =  300.0 F = 148.9 C
ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.    STACK PRESSURE = 30.00 IN. OF HG    MAX. PARTICLE DIAMETER = 168.0 MICROMETERS
GAS COMPOSITION (PERCENT)         CO2 = 12.88         CO =  0.00          N2 = 73.60          O2 =  5.52          H2O =  8.00
CALC. MASS LOADING = 2.7745E-01 GR/ACF            4.3161E-01 GR/DNCF          6.3490E+02 MG/ACM            9.8767E+02 MG/DNCM
IMPACTOR STAGE                                    S1        S2        S3        S4        S5              FILTER
STAGE INDEX NUMBER                                1         2         3         4         5               6
D50 (MICROMETERS)                              3.58      2.25      1.72      0.72      0.53
MASS (MILLIGRAMS)                              2.90      2.16      1.63      1.18      0.30              0.19
MG/DNCM/STAGE                                  3.43E+02  2.55E+02  1.93E+02  1.39E+02  3.54E+01          2.24E+01
CUM. PERCENT OF MASS SMALLER THAN D50         65.31     39.47     19.98      5.86      2.27
CUM. (MG/ACM) SMALLER THAN D50                 4.15E+02  2.51E+02  1.27E+02  3.72E+01  1.44E+01
CUM. (MG/DNCM) SMALLER THAN D50                6.45E+02  3.90E+02  1.97E+02  5.79E+01  2.24E+01
CUM. (GR/ACF) SMALLER THAN D50                 1.81E-01  1.10E-01  5.54E-02  1.63E-02  6.31E-03
CUM. (GR/DNCF) SMALLER THAN D50                2.82E-01  1.70E-01  8.62E-02  2.53E-02  9.81E-03
GEO. MEAN DIA. (MICROMETERS)                   2.45E+01  2.84E+00  1.97E+00  1.12E+00  6.18E-01          3.73E-01
DM/DLOGD (MG/DNCM)                             2.05E+02  1.26E+03  1.64E+03  3.71E+02  2.56E+02          7.46E+01
DN/DLOGD (NO. PARTICLES/DNCM)                  1.10E+07  4.39E+10  1.72E+11  2.13E+11  8.65E+11          4.42E+11

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
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HYPOTHETICAL BRINK TEST - STAGE 1 - STAGE 5, FILTER

IMPACTOR FLOWRATE = 0.031 ACFM              IMPACTOR TEMPERATURE =  300.0 F = 148.9 C             SAMPLING DURATION =  15.00 MIN

IMPACTOR PRESSURE DROP = 0.4 IN. OF HG      STACK TEMPERATURE =  300.0 F = 148.9 C

ASSUMED PARTICLE DENSITY = 1.00 GM/CU.CM.     STACK PRESSURE = 30.00 IN. OF HG     MAX. PARTICLE DIAMETER = 260.3 MICROMETERS

GAS COMPOSITION (PERCENT)          CO2 = 12.88          CO =  0.00           N2 = 73.60          O2 =  5.52          H2O =  8.00

CALC. MASS LOADING = 2.7745E-01 GR/ACF           4.3161E-01 GR/DNCF              6.3490E+02 MG/ACM              9.8767E+02 MG/DNCM

IMPACTOR STAGE                                            S1        S2        S3        S4        S5                FILTER

STAGE INDEX NUMBER                                         1         2         3         4         5                   6

D50 (MICROMETERS)                                        5.73      3.66      2.84      1.29      0.98

MASS (MILLIGRAMS)                                        2.90      2.16      1.63      1.18      0.30                0.19

MG/DNCM/STAGE                                        3.43E+02  2.55E+02  1.93E+02  1.39E+02  3.54E+01            2.24E+01

CUM. PERCENT OF MASS SMALLER THAN D50                   65.31     39.47     19.98      5.86      2.27

CUM. (MG/ACM) SMALLER THAN D50                       4.15E+02  2.51E+02  1.27E+02  3.72E+01  1.44E+01

CUM. (MG/DNCM) SMALLER THAN D50                      6.45E+02  3.90E+02  1.97E+02  5.79E+01  2.24E+01

CUM. (GR/ACF) SMALLER THAN D50                       1.81E-01  1.10E-01  5.54E-02  1.63E-02  6.31E-03

CUM. (GR/DNCF) SMALLER THAN D50                      2.82E-01  1.70E-01  8.62E-02  2.53E-02  9.81E-03

GEO. MEAN DIA. (MICROMETERS)                         3.86E+01  4.58E+00  3.22E+00  1.91E+00  1.13E+00            6.95E-01

DM/DLOGD (MG/DNCM)                                   2.07E+02  1.31E+03  1.74E+03  4.07E+02  3.00E+02            7.46E+01

DN/DLOGD (NO. PARTICLES/DNCM)                        6.86E+06  2.61E+10  9.90E+10  1.11E+11  4.02E+11            1.88E+11


NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.

AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO MERCER.
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HYPOTHETICAL BRINK TEST - STAGE 1 - STAGE 5, FILTER
IMPACTOR FLOWRATE = 0.031 ACFM              IMPACTOR TEMPERATURE =  300.0 F = 148.9 C              SAMPLING DURATION =  15.00 MIN
IMPACTOR PRESSURE DROP = 0.4 IN. OF HG      STACK TEMPERATURE =  300.0 F = 148.9 C
ASSUMED PARTICLE DENSITY = 1.00 GM/CU.CM.    STACK PRESSURE = 30.00 IN. OF HG     MAX. PARTICLE DIAMETER = 260.3 MICROMETERS
GAS COMPOSITION (PERCENT)         CO2 = 12.88         CO =  0.00           N2 = 73.60          O2 =  5.52          H2O =  8.00
CALC. MASS LOADING = 2.7745E-01 GR/ACF          4.3161E-01 GR/DNCF           6.3490E+02 MG/ACM            9.8767E+02 MG/DNCM
IMPACTOR STAGE                                         S1         S2         S3         S4         S5                 FILTER
STAGE INDEX NUMBER                                     1          2          3          4          5                   6
D50 (MICROMETERS)                                    5.61       3.55       2.72       1.18       0.87
MASS (MILLIGRAMS)                                    2.90       2.16       1.63       1.18       0.30                0.19
MG/DNCM/STAGE                                      3.43E+02   2.55E+02   1.93E+02   1.39E+02   3.54E+01            2.24E+01
CUM. PERCENT OF MASS SMALLER THAN D50               65.31      39.47      19.98       5.86       2.27
CUM. (MG/ACM) SMALLER THAN D50                     4.15E+02   2.51E+02   1.27E+02   3.72E+01   1.44E+01
CUM. (MG/DNCM) SMALLER THAN D50                    6.45E+02   3.90E+02   1.97E+02   5.79E+01   2.24E+01
CUM. (GR/ACF) SMALLER THAN D50                     1.81E-01   1.10E-01   5.54E-02   1.63E-02   6.31E-03
CUM. (GR/DNCF) SMALLER THAN D50                    2.82E-01   1.70E-01   8.62E-02   2.53E-02   9.81E-03
GEO. MEAN DIA. (MICROMETERS)                       3.82E+01   4.46E+00   3.11E+00   1.79E+00   1.02E+00            6.18E-01
DM/DLOGD (MG/DNCM)                                 2.06E+02   1.28E+03   1.68E+03   3.84E+02   2.72E+02            7.46E+01
DN/DLOGD (NO. PARTICLES/DNCM)                      7.03E+06   2.75E+10   1.06E+11   1.27E+11   4.96E+11            2.45E+11

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO THE TASK GROUP ON LUNG DYNAMICS.
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HYPOTHETICAL BRINK TEST - STAGE 1 - STAGE 6, NO FILTER
IMPACTOR FLOWRATE = 0.031 ACFM            IMPACTOR TEMPERATURE =  300.0 F = 148.9 C              SAMPLING DURATION =  15.00 MIN
IMPACTOR PRESSURE DROP = 1.2 IN. OF HG    STACK TEMPERATURE =  300.0 F = 148.9 C
ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.   STACK PRESSURE = 30.00 IN. OF HG    MAX. PARTICLE DIAMETER = 168.0 MICROMETERS
GAS COMPOSITION (PERCENT)         CO2 = 12.88        CO =  0.00         N2 = 73.60        O2 =  5.52        H2O =  8.00
CALC. MASS LOADING = 2.7446E-01 GR/ACF          4.2696E-01 GR/DNCF           6.2807E+02 MG/ACM           9.7703E+02 MG/DNCM
IMPACTOR STAGE                                 S1        S2        S3        S4        S5        S6      FILTER
STAGE INDEX NUMBER                             1         2         3         4         5         6         7
D50 (MICROMETERS)                            3.58      2.25      1.72      0.72      0.53      0.25
MASS (MILLIGRAMS)                            2.90      2.16      1.63      1.18      0.30      0.10      0.00
MG/DNCM/STAGE                              3.43E+02  2.55E+02  1.93E+02  1.39E+02  3.54E+01  1.18E+01  0.00E-01
CUM. PERCENT OF MASS SMALLER THAN D50       64.93     38.81     19.11      4.84      1.21      0.00
CUM. (MG/ACM) SMALLER THAN D50             4.08E+02  2.44E+02  1.20E+02  3.04E+01  7.59E+00  0.00E-01
CUM. (MG/DNCM) SMALLER THAN D50            6.34E+02  3.79E+02  1.87E+02  4.73E+01  1.18E+01  0.00E-01
CUM. (GR/ACF) SMALLER THAN D50             1.78E-01  1.07E-01  5.24E-02  1.33E-02  3.32E-03  0.00E-01
CUM. (GR/DNCF) SMALLER THAN D50            2.77E-01  1.66E-01  8.16E-02  2.07E-02  5.16E-03  0.00E-01
GEO. MEAN DIA. (MICROMETERS)               2.45E+01  2.84E+00  1.97E+00  1.12E+00  6.17E-01  3.63E-01  3.71E-01
DM/DLOGD (MG/DNCM)                         2.05E+02  1.26E+03  1.64E+03  3.71E+02  2.55E+02  3.68E+01  0.00E-01
DN/DLOGD (NO. PARTICLES/DNCM)              1.10E+07  4.39E+10  1.72E+11  2.13E+11  8.65E+11  6.12E+11  0.00E-01

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
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HYPOTHETICAL BRINK TEST - STAGE 1 - STAGE 6, NO FILTER                                  SAMPLING DURATION =  15.00 MIN
                                     IMPACTOR TEMPERATURE =  300.0 F = 148.9 C
IMPACTOR FLOWRATE = 0.031 ACFM
                                     STACK TEMPERATURE =  300.0 F = 148.9 C
IMPACTOR PRESSURE DROP = 1.2 IN. OF HG
                                     STACK PRESSURE = 30.00 IN. OF HG      MAX. PARTICLE DIAMETER = 260.3 MICROMETERS
ASSUMED PARTICLE DENSITY = 1.00 GM/CU.CM.
                                                                                                               H2O =  8.00
                               CO2 = 12.88          CO =  0.00            N2 = 73.60          O2 =  5.52
GAS COMPOSITION (PERCENT)
                                                                                                   9.7703E+02 MG/DNCM
                                              4.2696E-01 GR/DNCF          6.2807E+02 MG/ACM
CALC. MASS LOADING = 2.7446E-01 GR/ACF
                                                                                               S5        S6      FILTER
                                                        S1        S2        S3        S4
IMPACTOR STAGE                                                                                           6         7
                                                        1         2         3         4         5
STAGE INDEX NUMBER                                                                                      0.56
                                                      5.73      3.66      2.84      1.29      0.98
D50 (MICROMETERS)                                                                                       0.10      0.00
                                                      2.90      2.16      1.63      1.18      0.30
MASS (MILLIGRAMS)                                                                                   1.18E+01  0.00E-01
                                                   3.43E+02  2.55E+02  1.93E+02  1.39E+02  3.54E+01
MG/DNCM/STAGE                                                                                          0.00
                                                     64.93     38.81     19.11      4.84      1.21
CUM. PERCENT OF MASS SMALLER THAN D50                                                          0.00E-01
                                                   4.08E+02  2.44E+02  1.20E+02  3.04E+01  7.59E+00
CUM. (MG/ACM) SMALLER THAN D50                                                                 0.00E-01
                                                   6.34E+02  3.79E+02  1.87E+02  4.73E+01  1.18E+01
CUM. (MG/DNCM) SMALLER THAN D50                                                                0.00E-01
                                                   1.78E-01  1.07F-01  5.24E-02  1.33E-02  3.32E-03
CUM. (GR/ACF) SMALLER THAN D50                                                                 0.00E-01
                                                   2.77E-01  1.66E-01  8.16E-02  2.07E-02  5.16E-03
CUM. (GR/DNCF) SMALLER THAN D50                                                                7.39E-01  6.93E-01
                                                   3.86E+01  4.58E+00  3.22E+00  1.91E+00  1.12E+00
GEO. MEAN DIA. (MICROMETERS)                                                                   4.81E+01  0.00E-01
                                                   2.07E+02  1.31E+03  1.73E+03  4.07E+02  2.99E+02
DM/DLOGD (MG/DNCM)                                                                             2.28E+11  0.00E-01
                                                   6.86E+06  2.61E+10  9.90E+10  1.11E+11  4.01E+11
DN/DLOGD (NO. PARTICLES/DNCM)

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO MERCER.
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HYPOTHETICAL BRINK TEST - STAGE 1 - STAGE 6, NO FILTER
IMPACTOR FLOWRATE = 0.031 ACFM            IMPACTOR TEMPERATURE =  300.0 F = 148.9 C           SAMPLING DURATION =  15.00 MIN
IMPACTOR PRESSURE DROP = 1.2 IN. OF HG     STACK TEMPERATURE =  300.0 F = 148.9 C
ASSUMED PARTICLE DENSITY = 1.00 GM/CU.CM.    STACK PRESSURE = 30.00 IN. OF HG    MAX. PARTICLE DIAMETER = 260.3 MICROMETERS
GAS COMPOSITION (PERCENT)        CO2 = 12.88        CO =  0.00        N2 = 73.60        O2 =  5.52        H2O =  8.00
CALC. MASS LOADING = 2.7446E-01 GR/ACF            4.2696E-01 GR/DNCF        6.2807E+02 MG/ACM          9.7703E+02 MG/DNCM
IMPACTOR STAGE                                       S1        S2        S3        S4        S5        S6      FILTER
STAGE INDEX NUMBER                                    1         2         3         4         5         6         7
D50 (MICROMETERS)                                  5.61      3.55      2.72      1.18      0.87      0.45
MASS (MILLIGRAMS)                                  2.90      2.16      1.63      1.18      0.30      0.10      0.00
MG/DNCM/STAGE                                  3.43E+02  2.55E+02  1.93E+02  1.39E+02  3.54E+01  1.18E+01  0.00E-01
CUM. PERCENT OF MASS SMALLER THAN D50             64.93     38.81     19.11      4.84      1.21      0.00
CUM. (MG/ACM) SMALLER THAN D50                 4.08E+02  2.44E+02  1.20E+02  3.04E+01  7.59E+00  0.00E-01
CUM. (MG/DNCM) SMALLER THAN D50                6.34E+02  3.79E+02  1.87E+02  4.73E+01  1.18E+01  0.00E-01
CUM. (GR/ACF) SMALLER THAN D50                 1.78E-01  1.07E-01  5.24E-02  1.33E-02  3.32E-03  0.00E-01
CUM. (GR/DNCF) SMALLER THAN D50                2.77E-01  1.66E-01  8.16E-02  2.07E-02  5.16E-03  0.00E-01
GEO. MEAN DIA. (MICROMETERS)                   3.82E+01  4.46E+00  3.11E+00  1.79E+00  1.01E+00  6.23E-01  6.16E-01
DM/DLOGD (MG/DNCM)                             2.06E+02  1.28E+03  1.67E+03  3.83E+02  2.70E+02  4.06E+01  0.00E-01
DN/DLOGD (NO. PARTICLES/DNCM)                  7.03E+06  2.75E+10  1.06E+11  1.27E+11  4.95E+11  3.20E+11  0.00E-01

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO THE TASK GROUP ON LUNG DYNAMICS.
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HYPOTHETICAL BRINK TEST - STAGE 1 - STAGE 5, NO FILTER

IMPACTOR FLOWRATE = 0.031 ACFM               IMPACTOR TEMPERATURE =  300.0 F = 148.9 C              SAMPLING DURATION =  15.00 MIN

IMPACTOR PRESSURE DROP = 0.4 IN. OF HG       STACK TEMPERATURE =  300.0 F = 148.9 C

ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.     STACK PRESSURE = 30.00 IN. OF HG     MAX. PARTICLE DIAMETER = 168.0 MICROMETERS

GAS COMPOSITION (PERCENT)           CO2 = 12.88          CO =  0.00            N2 = 73.60           O2 =  5.52           H2O =  8.00

CALC. MASS LOADING = 2.7115E-01 GR/ACF            4.2180E-01 GR/DNCF              6.2047E+02 MG/ACM             9.6522E+02 MG/DNCM

IMPACTOR STAGE                                                S1         S2         S3         S4         S5               FILTER

STAGE INDEX NUMBER                                            1          2          3          4          5                 6

D50 (MICROMETERS)                                           3.58       2.25       1.72       0.72       0.53

MASS (MILLIGRAMS)                                           2.90       2.16       1.63       1.18       0.30              0.00

MG/DNCM/STAGE                                            3.43E+02   2.55E+02   1.93E+02   1.39E+02   3.54E+01          0.00E-01

CUM. PERCENT OF MASS SMALLER THAN D50                      64.50      38.07      18.12       3.67       0.00

CUM. (MG/ACM) SMALLER THAN D50                           4.00E+02   2.36E+02   1.12E+02   2.28E+01   0.00E-01

CUM. (MG/DNCM) SMALLER THAN D50                          6.23E+02   3.67E+02   1.75E+02   3.54E+01   0.00E-01

CUM. (GR/ACF) SMALLER THAN D50                           1.75E-01   1.03E-01   4.91E-02   9.96E-03   0.00E-01

CUM. (GR/DNCF) SMALLER THAN D50                          2.72E-01   1.61E-01   7.64E-02   1.55E-02   0.00E-01

GEO. MEAN DIA. (MICROMETERS)                             2.45E+01   2.84E+00   1.97E+00   1.12E+00   6.18E-01          3.73E-01

DM/DLOGD (MG/DNCM)                                       2.05E+02   1.26E+03   1.64E+03   3.71E+02   2.56E+02          0.00E-01

DN/DLOGD (NO. PARTICLES/DNCM)                            1.10E+07   4.39E+10   1.72E+11   2.13E+11   8.65E+11          0.00E-01


NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
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HYPOTHETICAL BRINK TEST - STAGE 1 - STAGE 5, NO FILTER
IMPACTOR FLOWRATE = 0.031 ACFM              IMPACTOR TEMPERATURE =  300.0 F = 148.9 C              SAMPLING DURATION =  15.00 MIN
IMPACTOR PRESSURE DROP = 0.4 IN. OF HG      STACK TEMPERATURE =  300.0 F = 148.9 C
ASSUMED PARTICLE DENSITY = 1.00 GM/CU.CM.    STACK PRESSURE = 30.00 IN. OF HG     MAX. PARTICLE DIAMETER = 260.3 MICROMETERS
GAS COMPOSITION (PERCENT)          CO2 = 12.88          CO =  0.00          N2 = 73.60          O2 =  5.52          H2O =  8.00
CALC. MASS LOADING = 2.7115E-01 GR/ACF            4.2180E-01 GR/DNCF            6.2047E+02 MG/ACM            9.6522E+02 MG/DNCM
IMPACTOR STAGE                                   S1         S2         S3         S4         S5                FILTER
STAGE INDEX NUMBER                                1          2          3          4          5                  6
D50 (MICROMETERS)                               5.73       3.66       2.84       1.29       0.98
MASS (MILLIGRAMS)                               2.90       2.16       1.63       1.18       0.30                0.00
MG/DNCM/STAGE                                   3.43E+02   2.55E+02   1.93E+02   1.39E+02   3.54E+01            0.00E-01
CUM. PERCENT OF MASS SMALLER THAN D50          64.50      38.07      18.12       3.67       0.00
CUM. (MG/ACM) SMALLER THAN D50                  4.00E+02   2.36E+02   1.12E+02   2.28E+01   0.00E-01
CUM. (MG/DNCM) SMALLER THAN D50                 6.23E+02   3.67E+02   1.75E+02   3.54E+01   0.00E-01
CUM. (GR/ACF) SMALLER THAN D50                  1.75E-01   1.03E-01   4.91E-02   9.96E-03   0.00E-01
CUM. (GR/DNCF) SMALLER THAN D50                 2.72E-01   1.61E-01   7.64E-02   1.55E-02   0.00E-01
GEO. MEAN DIA. (MICROMETERS)                    3.86E+01   4.58E+00   3.22E+00   1.91E+00   1.13E+00            6.95E-01
DM/DLOGD (MG/DNCM)                              2.07E+02   1.31E+03   1.74E+03   4.07E+02   3.00E+02            0.00E-01
DN/DLOGD (NO. PARTICLES/DNCM)                   6.86E+06   2.61E+10   9.90E+10   1.11E+11   4.02E+11            0.00E-01

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO MERCER.
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HYPOTHETICAL BRINK TEST - STAGE 1 - STAGE 5, NO FILTER
IMPACTOR FLOWRATE = 0.031 ACFM              IMPACTOR TEMPERATURE =  300.0 F = 148.9 C              SAMPLING DURATION =  15.00 MIN
IMPACTOR PRESSURE DROP = 0.4 IN. OF HG      STACK TEMPERATURE =  300.0 F = 148.9 C
ASSUMED PARTICLE DENSITY = 1.00 GM/CU.CM.    STACK PRESSURE = 30.00 IN. OF HG     MAX. PARTICLE DIAMETER = 260.3 MICROMETERS
GAS COMPOSITION (PERCENT)          CO2 = 12.88          CO =  0.00            N2 = 73.60            O2 =  5.52            H2O =  8.00
CALC. MASS LOADING = 2.7115E-01 GR/ACF              4.2180E-01 GR/DNCF              6.2047E+02 MG/ACM              9.6522E+02 MG/DNCM
IMPACTOR STAGE                                    S1        S2        S3        S4        S5                  FILTER
STAGE INDEX NUMBER                                1         2         3         4         5                   6
D50 (MICROMETERS)                                 5.61      3.55      2.72      1.18      0.87
MASS (MILLIGRAMS)                                 2.90      2.16      1.63      1.18      0.30                0.00
MG/DNCM/STAGE                                     3.43E+02  2.55E+02  1.93E+02  1.39E+02  3.54E+01            0.00E-01
CUM. PERCENT OF MASS SMALLER THAN D50            64.50     38.07     18.12      3.67      0.00
CUM. (MG/ACM) SMALLER THAN D50                    4.00E+02  2.36E+02  1.12E+02  2.28E+01  0.00E-01
CUM. (MG/DNCM) SMALLER THAN D50                   6.23E+02  3.67E+02  1.75E+02  3.54E+01  0.00E-01
CUM. (GR/ACF) SMALLER THAN D50                    1.75E-01  1.03E-01  4.91E-02  9.96E-03  0.00E-01
CUM. (GR/DNCF) SMALLER THAN D50                   2.72E-01  1.61E-01  7.64E-02  1.55E-02  0.00E-01
GEO. MEAN DIA. (MICROMETERS)                      3.82E+01  4.46E+00  3.11E+00  1.79E+00  1.02E+00            6.18E-01
DM/DLOGD (MG/DNCM)                                2.06E+02  1.28E+03  1.68E+03  3.84E+02  2.72E+02            0.00E-01
DN/DLOGD (NO. PARTICLES/DNCM)                     7.03E+06  2.75E+10  1.06E+11  1.27E+11  4.96E+11            0.00E-01

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO THE TASK GROUP ON LUNG DYNAMICS.
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CARD COLUMN
NUMBERS

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                    DATA DECK FOR PROGRAM  MPPROG

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  0.67  0.40  1.80  4.01  5.81  3.01  2.61  5.93
 0.500
HYPOTHETICAL UNIVERSITY OF WASHINGTON MARK III
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HYPOTHETICAL UNIVERSITY OF WASHINGTON MARK III
IMPACTOR FLOWRATE = 0.500 ACFM           IMPACTOR TEMPERATURE =  213.3 F = 100.7 C            SAMPLING DURATION =  30.00 MIN
IMPACTOR PRESSURE DROP = 1.0 IN. OF HG   STACK TEMPERATURE =  213.3 F = 100.7 C
ASSUMED PARTICLE DENSITY = 2.34 GM/CU.CM.   STACK PRESSURE = 22.96 IN. OF HG    MAX. PARTICLE DIAMETER = 200.0 MICROMETERS
GAS COMPOSITION (PERCENT)          CO2 = 11.99         CO =  0.00          N2 = 74.34         O2 =  5.02         H2O =  8.65
CALC. MASS LOADING = 2.4939E-02 GR/ACF          4.5223E-02 GR/DNCF          5.7068E+01 MG/ACM          1.0349E+02 MG/DNCM
IMPACTOR STAGE                          S1        S2        S3        S4        S5        S6        S7      FILTER
STAGE INDEX NUMBER                       1         2         3         4         5         6         7         8
D50 (MICROMETERS)                     7.90      8.11      3.42      1.45      0.74      0.50      0.16
MASS (MILLIGRAMS)                     5.93      2.61      3.01      5.81      4.01      1.80      0.40      0.67
MG/DSCM/STAGE                     2.53E+01  1.11E+01  1.29E+01  2.48E+01  1.71E+01  7.68E+00  1.71E+00  2.86E+00
CUM. PERCENT OF MASS SMALLER THAN D50  75.54     64.77     52.35     28.38     11.84      4.41      2.76
CUM. (MG/ACM) SMALLER THAN D50    4.31E+01  3.70E+01  2.99E+01  1.62E+01  6.76E+00  2.52E+00  1.58E+00
CUM. (MG/DNCM) SMALLER THAN D50   7.82E+01  6.70E+01  5.42E+01  2.94E+01  1.23E+01  4.57E+00  2.86E+00
CUM. (GR/ACF) SMALLER THAN D50    1.88E-02  1.62E-02  1.31E-02  7.08E-03  2.95E-03  1.10E-03  6.89E-04
CUM. (GR/DNCF) SMALLER THAN D50   3.42E-02  2.93E-02  2.37E-02  1.28E-02  5.35E-03  2.00E-03  1.25E-03
GEO. MEAN DIA. (MICROMETERS)      3.97E+01  8.00E+00  5.27E+00  2.23E+00  1.03E+00  6.06E-01  2.81E-01  1.12E-01
DM/DLOGD (MG/DNCM)                1.80E+01 -9.80E+02  3.43E+01  6.66E+01  5.82E+01  4.51E+01  3.44E+00  9.50E+00
DN/DLOGD (NO. PARTICLES/DNCM)     2.35E+05 -1.56E+09  1.92E+08  4.92E+09  4.29E+10  1.66E+11  1.26E+11  5.48E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
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HYPOTHETICAL UNIVERSITY OF WASHINGTON MARK III

IMPACTOR FLOWRATE = 0,500 ACFM              IMPACTOR TEMPERATURE =  213,3 F = 100,7 C              SAMPLING DURATION =  30,00 MIN

IMPACTOR PRESSURE DROP = 1,0 IN, OF HG      STACK TEMPERATURE =  213,3 F = 100,7 C

ASSUMED PARTICLE DENSITY = 1,00 GM/CU,CM,     STACK PRESSURE = 22,96 IN, OF HG     MAX, PARTICLE DIAMETER = 305,9 MICROMETERS

GAS COMPOSITION (PERCENT)          CO2 = 11,99          CO =  0,00          N2 = 74,34          O2 =  5,02          H2O =  8,65

CALC, MASS LOADING = 2,4939E-02 GR/ACF          4,5223E-02 GR/DNCF          5,7068E+01 MG/ACM          1,0349E+02 MG/DNCM

IMPACTOR STAGE                              S1        S2        S3        S4        S5        S6        S7     FILTER

STAGE INDEX NUMBER                           1         2         3         4         5         6         7         8

D50 (MICROMETERS)                         12,28     12,60      5,02      2,41      1,31      0,95      0,42

MASS (MILLIGRAMS)                          5,93      2,61      3,01      5,81      4,01      1,80      0,40      0,67

MG/DSCM/STAGE                          2,53E+01  1,11E+01  1,29E+01  2,48E+01  1,71E+01  7,68E+00  1,71E+00  2,86E+00

CUM, PERCENT OF MASS SMALLER THAN D50    75,54     64,77     52,35     28,38     11,84      4,41      2,76

CUM, (MG/ACM) SMALLER THAN D50         4,31E+01  3,70E+01  2,99E+01  1,62E+01  6,76E+00  2,52E+00  1,58E+00

CUM, (MG/DNCM) SMALLER THAN D50        7,82E+01  6,70E+01  5,42E+01  2,94E+01  1,23E+01  4,57E+00  2,86E+00

CUM, (GR/ACF) SMALLER THAN D50         1,88E-02  1,62E-02  1,31E-02  7,08E-03  2,95E-03  1,10E-03  6,89E-04

CUM, (GR/DNCF) SMALLER THAN D50        3,42E-02  2,93E-02  2,37E-02  1,28E-02  5,35E-03  2,00E-03  1,25E-03

GEO, MEAN DIA, (MICROMETERS)           6,13E+01  1,24E+01  8,27E+00  3,61E+00  1,78E+00  1,12E+00  6,32E-01  2,97E-01

DM/DLOGD (MG/DNCM)                     1,81E+01 -9,96E+02  3,51E+01  7,04E+01  6,49E+01  5,46E+01  4,83E+00  9,50E+00

DN/DLOGD (NO, PARTICLES/DNCM)          1,50E+05 -9,89E+08  1,19E+08  2,84E+09  2,21E+10  7,50E+10  3,66E+10  6,92E+11


NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO MERCER,
HYPOTHETICAL UNIVERSITY OF WASHINGTON MARK III

IMPACTOR FLOWRATE = 0.500 ACFM            IMPACTOR TEMPERATURE =  213.3 F = 100.7 C             SAMPLING DURATION =  30.00 MIN

IMPACTOR PRESSURE DROP = 1.0 IN. OF HG     STACK TEMPERATURE =  213.3 F = 100.7 C

ASSUMED PARTICLE DENSITY = 1.00 GM/CU.CM.    STACK PRESSURE = 22.96 IN. OF HG     MAX. PARTICLE DIAMETER = 305.9 MICROMETERS

GAS COMPOSITION (PERCENT)          CO2 = 11.99          CO =  0.00          N2 = 74.34          O2 =  5.02          H2O =  8.65

CALC. MASS LOADING = 2.4939E-02 GR/ACF            4.5223E-02 GR/DNCF             5.7068E+01 MG/ACM            1.0349E+02 MG/DNCM

IMPACTOR STAGE                            S1        S2        S3        S4        S5        S6        S7      FILTER

STAGE INDEX NUMBER                        1         2         3         4         5         6         7         8

D50 (MICROMETERS)                       12.15     12.47      5.30      2.28      1.19      0.82      0.30

MASS (MILLIGRAMS)                        5.93      2.61      3.01      5.81      4.01      1.80      0.40      0.67

MG/DSCM/STAGE                          2.53E+01  1.11E+01  1.29E+01  2.48E+01  1.71E+01  7.68E+00  1.71E+00  2.86E+00

CUM. PERCENT OF MASS SMALLER THAN D50   75.54     64.77     52.35     28.38     11.84      4.41      2.76

CUM. (MG/ACM) SMALLER THAN D50         4.31E+01  3.70E+01  2.99E+01  1.62E+01  6.76E+00  2.52E+00  1.58E+00

CUM. (MG/DNCM) SMALLER THAN D50        7.82E+01  6.70E+01  5.42E+01  2.94E+01  1.23E+01  4.57E+00  2.86E+00

CUM. (GR/ACF) SMALLER THAN D50         1.88E-02  1.62E-02  1.31E-02  7.08E-03  2.95E-03  1.10E-03  6.89E-04

CUM. (GR/DNCF) SMALLER THAN D50        3.42E-02  2.93E-02  2.37E-02  1.28E-02  5.35E-03  2.00E-03  1.25E-03

GEO. MEAN DIA. (MICROMETERS)           6.10E+01  1.23E+01  8.13E+00  3.48E+00  1.65E+00  9.91E-01  4.95E-01  2.10E-01

DM/DLOGD (MG/DNCM)                     1.81E+01 -9.86E+02  3.46E+01  6.79E+01  6.04E+01  4.83E+01  3.85E+00  9.50E+00

DN/DLOGD (NO. PARTICLES/DNCM)          1.52E+05 -1.01E+09  1.23E+08  3.08E+09  2.58E+10  9.50E+10  6.06E+10  1.95E+12


NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.

AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO THE TASK GROUP ON LUNG DYNAMICS.
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DATA DECK FOR PROGRAM MPPROG

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HYPOTHETICAL METEOROLOGY RESEARCH, INC.
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STOP  000000
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HYPOTHETICAL METEOROLOGY RESEARCH, INC.

IMPACTOR FLOWRATE = 0.500 ACFM            IMPACTOR TEMPERATURE =  213.3 F = 100.7 C            SAMPLING DURATION =  30.00 MIN

IMPACTOR PRESSURE DROP = 2.3 IN. OF HG    STACK TEMPERATURE =  213.3 F = 100.7 C

ASSUMED PARTICLE DENSITY = 2.34 GM/CU.CM.   STACK PRESSURE = 22.96 IN. OF HG    MAX. PARTICLE DIAMETER = 200.0 MICROMETERS

GAS COMPOSITION (PERCENT)         CO2 = 11.99        CO =  0.00          N2 = 74.34         O2 =  5.02          H2O =  8.65

CALC. MASS LOADING = 2.4939E-02 GR/ACF          4.5223E-02 GR/DNCF          5.7068E+01 MG/ACM          1.0349E+02 MG/DNCM

IMPACTOR STAGE                              S1        S2        S3        S4        S5        S6        S7      FILTER

STAGE INDEX NUMBER                           1         2         3         4         5         6         7         8

D50 (MICROMETERS)                          5.59      6.31      3.47      1.40      0.66      0.33      0.22

MASS (MILLIGRAMS)                          5.93      2.61      3.01      5.81      4.01      1.80      0.40      0.67

MG/DSCM/STAGE                            2.53E+01  1.11E+01  1.29E+01  2.48E+01  1.71E+01  7.68E+00  1.71E+00  2.86E+00

CUM. PERCENT OF MASS SMALLER THAN D50   75.54     64.77     52.35     28.38     11.84      4.41      2.76

CUM. (MG/ACM) SMALLER THAN D50           4.31E+01  3.70E+01  2.99E+01  1.62E+01  6.76E+00  2.52E+00  1.58E+00

CUM. (MG/DNCM) SMALLER THAN D50          7.82E+01  6.70E+01  5.42E+01  2.94E+01  1.23E+01  4.57E+00  2.86E+00

CUM. (GR/ACF) SMALLER THAN D50           1.88E-02  1.62E-02  1.31E-02  7.08E-03  2.95E-03  1.10E-03  6.89E-04

CUM. (GR/DNCF) SMALLER THAN D50          3.42E-02  2.93E-02  2.37E-02  1.28E-02  5.35E-03  2.00E-03  1.25E-03

GEO. MEAN DIA. (MICROMETERS)             3.34E+01  5.94E+00  4.68E+00  2.21E+00  9.62E-01  4.69E-01  2.74E-01  1.59E-01

DM/DLOGD (MG/DNCM)                       1.63E+01 -2.11E+02  4.96E+01  6.30E+01  5.22E+01  2.60E+01  9.91E+00  9.50E+00

DN/DLOGD (NO. PARTICLES/DNCM)            3.56E+05 -8.23E+08  3.95E+08  4.77E+09  4.78E+10  2.05E+11  3.94E+11  1.94E+12


NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
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HYPOTHETICAL METEOROLOGY RESEARCH, INC.

IMPACTOR FLOWRATE = 0.500 ACFM              IMPACTOR TEMPERATURE =  213.3 F = 100.7 C              SAMPLING DURATION =  30.00 MIN

IMPACTOR PRESSURE DROP = 2.3 IN. OF HG      STACK TEMPERATURE =  213.3 F = 100.7 C

ASSUMED PARTICLE DENSITY = 1.00 GM/CU.CM.    STACK PRESSURE = 22.96 IN. OF HG     MAX. PARTICLE DIAMETER = 305.9 MICROMETERS

GAS COMPOSITION (PERCENT)        CO2 = 11.99          CO =  0.00           N2 = 74.34          O2 =  5.02          H2O =  8.65

CALC. MASS LOADING = 2.4939E-02 GR/ACF            4.5223E-02 GR/DNCF            5.7068E+01 MG/ACM            1.0349E+02 MG/DNCM

IMPACTOR STAGE                          S1        S2        S3        S4        S5        S6        S7      FILTER

STAGE INDEX NUMBER                       1         2         3         4         5         6         7         8

D50 (MICROMETERS)                      8.74      9.84      5.51      2.34      1.19      0.70      0.54

MASS (MILLIGRAMS)                      5.93      2.61      3.01      5.81      4.01      1.80      0.40      0.67

MG/DSCM/STAGE                       2.53E+01  1.11E+01  1.29E+01  2.48E+01  1.71E+01  7.68E+00  1.71E+00  2.86E+00

CUM. PERCENT OF MASS SMALLER THAN D50  79.54     64.77     52.35     28.38     11.84      4.41      2.76

CUM. (MG/ACM) SMALLER THAN D50      4.31E+01  3.70E+01  2.99E+01  1.62E+01  6.76E+00  2.52E+00  1.58E+00

CUM. (MG/DNCM) SMALLER THAN D50     7.82E+01  6.70E+01  5.42E+01  2.94E+01  1.23E+01  4.57E+00  2.86E+00

CUM. (GR/ACF) SMALLER THAN D50      1.88E-02  1.62E-02  1.31E-02  7.08E-03  2.95E-03  1.10E-03  6.89E-04

CUM. (GR/DNCF) SMALLER THAN D50     3.42E-02  2.93E-02  2.37E-02  1.28E-02  5.35E-03  2.00E-03  1.25E-03

GEO. MEAN DIA. (MICROMETERS)        5.17E+01  9.28E+00  7.36E+00  3.59E+00  1.67E+00  9.12E-01  6.12E-01  3.81E-01

DM/DLOGD (MG/DNCM)                  1.64E+01 -2.15E+02  5.10E+01  6.66E+01  5.87E+01  3.28E+01  1.54E+01  9.50E+00

DN/DLOGD (NO. PARTICLES/DNCM)       2.26E+05 -5.16E+08  2.44E+08  2.75E+09  2.41E+10  8.25E+10  1.28E+11  3.28E+11


NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.

AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO MERCER.
STOP  000000
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HYPOTHETICAL METEOROLOGY RESEARCH, INC,

IMPACTOR FLOWRATE = 0,500 ACFM            IMPACTOR TEMPERATURE =  213,3 F = 100,7 C            SAMPLING DURATION =  30,00 MIN

IMPACTOR PRESSURE DROP = 2,3 IN, OF HG     STACK TEMPERATURE =  213,3 F = 100,7 C

ASSUMED PARTICLE DENSITY = 1,00 GM/CU,CM,    STACK PRESSURE = 22,96 IN, OF HG     MAX, PARTICLE DIAMETER = 305,9 MICROMETERS

GAS COMPOSITION (PERCENT)          CO2 = 11,99          CO =  0,00          N2 = 74,34          O2 =  5,02          H2O =  8,65

CALC, MASS LOADING = 2,4939E-02 GR/ACF          4,5223E-02 GR/DNCF          5,7068E+01 MG/ACM          1,0349E+02 MG/DNCM

IMPACTOR STAGE                         S1        S2        S3        S4        S5        S6        S7     FILTER

STAGE INDEX NUMBER                     1         2         3         4         5         6         7         8

D50 (MICROMETERS)                     8,61      9,72      5,38      2,21      1,07      0,57      0,41

MASS (MILLIGRAMS)                     5,93      2,61      3,01      5,81      4,01      1,80      0,40      0,67

MG/DSCM/STAGE                       2,53E+01  1,11E+01  1,29E+01  2,48E+01  1,71E+01  7,68E+00  1,71E+00  2,86E+00

CUM, PERCENT OF MASS SMALLER THAN D50   75,54     64,77     52,35     28,38     11,84      4,41      2,76

CUM, (MG/ACM) SMALLER THAN D50      4,31E+01  3,70E+01  2,99E+01  1,62E+01  6,76E+00  2,52E+00  1,58E+00

CUM, (MG/DNCM) SMALLER THAN D50     7,82E+01  6,70E+01  5,42E+01  2,94E+01  1,23E+01  4,57E+00  2,86E+00

CUM, (GR/ACF) SMALLER THAN D50      1,88E-02  1,62E-02  1,31E-02  7,08E-03  2,95E-03  1,10E-03  6,89E-04

CUM, (GR/DNCF) SMALLER THAN D5(     3,42E-02  2,93E-02  2,37E-02  1,28E-02  5,35E-03  2,00E-03  1,25E-03

GEO, MEAN DIA, (MICROMETERS)        5,13E+01  9,15E+00  7,23E+00  3,45E+00  1,54E+00  7,84E-01  4,83E-01  2,88E-01

DM/DLOGD (MG/DNCM)                  1,63E+01 -2,13E+02  5,01E+01  6,42E+01  5,44E+01  2,83E+01  1,15E+01  9,50E+00

DN/DLOGD (NO, PARTICLES/DNCM)       2,31E+05 -5,30E+08  2,53E+08  2,99E+09  2,85E+10  1,12E+11  1,94E+11  7,63E+11


NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

AERODYNAMIC DIAMETERS ARE CALCULATED HERE ACCORDING TO THE TASK GROUP ON LUNG DYNAMICS,
STOP  000000
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CARD COLUMN
NUMBERS

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                    DATA DECK FOR PROGRAM  MPPROG

         11111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
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0200
CIDRS VERSION 1 TEST FOR BRINK.
03
29.50 330.0 330.02.40 15.0168.01161
 .1400 .0000 .8000 .0600 .0800
 0.19  0.10  0.30  1.18  1.63  2.16  2.90  6.12 39.38
 0.0310
  COLI-4  1-13-76  1450  4UAI
04
29.50 330.0 330.02.40 15.0168.01161
 .1400 .0000 .8000 .0600 .0800
  0.23  0.30  0.43  1.45  1.16  2.83  1.97  2.37 49.15
 0.0310
  COLI-5  1-13-76  1715  2UAI
01
29.50 330.0 330.02.40 15.0168.01161
 .1400 .0000 .8000 .0600 .0800
  0.02  0.07  0.28  1.20  1.04  1.77  2.25  1.78 25.24
 0.0310
  COLI-7  1-13-76  1822  10UAI
01
30.00 340.0 340.02.40 15.0168.01161
 .1400 .0000 .8000 .0600 .0800
  0.14  0.00  0.16  0.58  0.84  0.48  0.86  0.75  8.21
 0.0310
  COLI-10  1-14-76  1520  1UAI
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04
30.00 345.0 345.02.40 15.0168.01161
 .1400 .0000 .8000 .0600 .0800
  0.14  0.06  0.19  0.44  0.83  0.80  1.06  1.11 19.96
 0.0310
  COLI-12  1-14 76  1600  5UAI
04
29.91 315.0 315.02.40 15.0168.01161
 .1400 .0000 .8000 .0600 .0800
  0.21  0.08  0.21  1.15  1.29  2.20  2.52  2.39 52.28
 0.0330
  COLI-13  1-15-76  1135  8UAI
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  COLI-4  1-13-76  1450  4UAT
IMPACTOR FLOWRATE = 0.031 ACFM            IMPACTOR TEMPERATURE =  330.0 F = 165.6 C            SAMPLING DURATION =  15.00 MIN
IMPACTOR PRESSURE DROP = 1.2 IN. OF HG    STACK TEMPERATURE =  330.0 F = 165.6 C
ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.   STACK PRESSURE = 29.50 IN. OF HG    MAX. PARTICLE DIAMETER = 168.0 MICROMETERS
GAS COMPOSITION (PERCENT)          CO2 = 12.88         CO =  0.00          N2 = 73.60          O2 =  5.52          H2O =  8.00
CALC. MASS LOADING = 1.7908E+00 GR/ACF             2.9450E+00 GR/DNCF             4.0980E+03 MG/ACM             6.7391E+03 MG/DNCM
IMPACTOR STAGE                              CYC       S0        S1        S2        S3        S4        S5        S6     FILTER
STAGE INDEX NUMBER                            1         2         3         4         5         6         7         8         9
D50 (MICROMETERS)                        11.00      6.68      3.63      2.28      1.74      0.73      0.53      0.25
MASS (MILLIGRAMS)                        39.38      6.12      2.90      2.16      1.63      1.18      0.30      0.10      0.19
MG/DNCM/STAGE                            4.92E+03  7.64E+02  3.62E+02  2.70E+02  2.04E+02  1.47E+02  3.75E+01  1.25E+01  2.37E+01
CUM. PERCENT OF MASS SMALLER THAN D50    27.02     15.68     10.30      6.30      3.28      1.09      0.54      0.35
CUM. (MG/ACM) SMALLER THAN D50           1.11E+03  6.42E+02  4.22E+02  2.58E+02  1.34E+02  4.48E+01  2.20E+01  1.44E+01
CUM. (MG/DNCM) SMALLER THAN D50          1.82E+03  1.06E+03  6.94E+02  4.25E+02  2.21E+02  7.37E+01  3.62E+01  2.37E+01
CUM. (GR/ACF) SMALLER THAN D50           4.84E-01  2.81E-01  1.85E-01  1.13E-01  5.87E-02  1.96E-02  9.62E-03  6.31E-03
CUM. (GR/DNCF) SMALLER THAN D50          7.96E-01  4.62E-01  3.03E-01  1.86E-01  9.66E-02  3.22E-02  1.58E-02  1.04E-02
GEO. MEAN DIA. (MICROMETERS)             4.30E+01  8.57E+00  4.92E+00  2.88E+00  1.99E+00  1.13E+00  6.20E-01  3.63E-01  1.76E-01
DM/DLOGD (MG/DNCM)                       4.15E+03  3.53E+03  1.37E+03  1.33E+03  1.73E+03  3.90E+02  2.67E+02  3.84E+01  7.88E+01
DN/DLOGD (NO. PARTICLES/DNCM)            4.16E+07  4.46E+09  9.11E+09  4.46E+10  1.75E+11  2.18E+11  8.91E+11  6.40E+11  1.14E+13


NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
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  COLI-5  1-13-76  1715  2UAT
IMPACTOR FLOWRATE = 0.031 ACFM            IMPACTOR TEMPERATURE =  330.0 F = 165.6 C           SAMPLING DURATION =  15.00 MIN
IMPACTOR PRESSURE DROP = 1.2 IN. OF HG     STACK TEMPERATURE =  330.0 F = 165.6 C
ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.    STACK PRESSURE = 29.50 IN. OF HG    MAX. PARTICLE DIAMETER = 168.0 MICROMETERS
GAS COMPOSITION (PERCENT)          CO2 = 12.88          CO =  0.00          N2 = 73.60          O2 =  5.52          H2O =  8.00
CALC. MASS LOADING = 1.9876E+00 GR/ACF          3.2686E+00 GR/DNCF          4.5484E+03 MG/ACM          7.4797E+03 MG/DNCM
IMPACTOR STAGE                           CYC       S0       S1       S2       S3       S4       S5       S6     FILTER
STAGE INDEX NUMBER                         1        2        3        4        5        6        7        8        9
D50 (MICROMETERS)                      11.00     6.41     3.63     2.36     1.59     0.70     0.53     0.16
MASS (MILLIGRAMS)                      49.15     2.37     1.97     2.83     1.16     1.45     0.43     0.30     0.23
MG/DNCM/STAGE                       6.14E+03 2.96E+02 2.46E+02 3.53E+02 1.45E+02 1.81E+02 5.37E+01 3.75E+01 2.87E+01
CUM. PERCENT OF MASS SMALLER THAN D50  17.93   13.98    10.69     5.96     4.02     1.60     0.88     0.38
CUM. (MG/ACM) SMALLER THAN D50      8.16E+02 6.36E+02 4.86E+02 2.71E+02 1.83E+02 7.29E+01 4.03E+01 1.75E+01
CUM. (MG/DNCM) SMALLER THAN D50     1.34E+03 1.05E+03 7.99E+02 4.46E+02 3.01E+02 1.20E+02 6.62E+01 2.87E+01
CUM. (GR/ACF) SMALLER THAN D50      3.56E-01 2.78E-01 2.12E-01 1.18E-01 8.00E-02 3.19E-02 1.76E-02 7.63E-03
CUM. (GR/DNCF) SMALLER THAN D50     5.86E-01 4.57E-01 3.49E-01 1.95E-01 1.32E-01 5.24E-02 2.89E-02 1.26E-02
GEO. MEAN DIA. (MICROMETERS)        4.30E+01 8.40E+00 4.82E+00 2.93E+00 1.94E+00 1.05E+00 6.08E-01 2.93E-01 1.14E-01
DM/DLOGD (MG/DNCM)                  5.18E+03 1.26E+03 9.98E+02 1.88E+03 8.50E+02 5.05E+02 4.50E+02 7.28E+01 9.54E+01
DN/DLOGD (NO. PARTICLES/DNCM)       5.20E+07 1.70E+09 7.07E+09 5.98E+10 9.31E+10 3.44E+11 1.59E+12 2.31E+12 5.06E+13

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
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  COLI-7  1-13-76  1822  10UAI
 IMPACTOR FLOWRATE = 0.031 ACFM            IMPACTOR TEMPERATURE =  330.0 F = 165.6 C              SAMPLING DURATION =  15.00 MIN
 IMPACTOR PRESSURE DROP = 1.2 IN. OF HG     STACK TEMPERATURE =  330.0 F = 165.6 C
 ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.   STACK PRESSURE = 29.50 IN. OF HG    MAX. PARTICLE DIAMETER = 168.0 MICROMETERS
 GAS COMPOSITION (PERCENT)          CO2 = 12.88        CO =  0.00          N2 = 73.60          O2 =  5.52          H2O =  8.00
 CALC. MASS LOADING = 1.1168E+00 GR/ACF           1.8365E+00 GR/DNCF           2.5556E+03 MG/ACM            4.2026E+03 MG/DNCM
 IMPACTOR STAGE                           CYC      S0       S1       S2       S3       S4       S5       S6     FILTER
 STAGE INDEX NUMBER                        1        2        3        4        5        6        7        8        9
 D50 (MICROMETERS)                       11.00     6.39     3.54     2.30     1.54     0.53     0.45     0.15
 MASS (MILLIGRAMS)                       25.24     1.78     2.25     1.77     1.04     1.20     0.28     0.07     0.02
 MG/DNCM/STAGE                          3.15E+03 2.22E+02 2.81E+02 2.21E+02 1.30E+02 1.50E+02 3.50E+01 8.74E+00 2.50E+00
 CUM. PERCENT OF MASS SMALLER THAN D50  24.99    19.70    13.02     7.76     4.67     1.10     0.27     0.06
 CUM. (MG/ACM) SMALLER THAN D50         6.39E+02 5.04E+02 3.33E+02 1.98E+02 1.19E+02 2.81E+01 6.84E+00 1.52E+00
 CUM. (MG/DNCM) SMALLER THAN D50        1.05E+03 8.28E+02 5.47E+02 3.26E+02 1.96E+02 4.62E+01 1.12E+01 2.50E+00
 CUM. (GR/ACF) SMALLER THAN D50         2.79E-01 2.20E-01 1.45E-01 8.66E-02 5.21E-02 1.23E-02 2.99E-03 6.64E-04
 CUM. (GR/DNCF) SMALLER THAN D50        4.59E-01 3.62E-01 2.39E-01 1.42E-01 8.57E-02 2.02E-02 4.91E-03 1.09E-03
 GEO. MEAN DIA. (MICROMETERS)           4.30E+01 8.38E+00 4.76E+00 2.86E+00 1.88E+00 9.06E-01 4.90E-01 2.57E-01 1.04E-01
 DM/DLOGD (MG/DNCM)                     2.66E+03 9.44E+02 1.10E+03 1.18E+03 7.45E+02 3.25E+02 4.82E+02 1.80E+01 8.30E+00
 DN/DLOGD (NO. PARTICLES/DNCM)          2.67E+07 1.27E+09 8.10E+09 4.03E+10 8.88E+10 3.48E+11 3.26E+12 8.40E+11 5.90E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
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  COLI-10  1-14-76  1520  10A1
 IMPACTOR FLOWRATE = 0.031 ACFM              IMPACTOR TEMPERATURE =  380.0 F = 171.1 C              SAMPLING DURATION =  15.00 MIN
 IMPACTOR PRESSURE DROP = 1.2 IN. OF HG      STACK TEMPERATURE =  380.0 F = 171.1 C
 ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.    STACK PRESSURE = 30.00 IN. OF HG    MAX. PARTICLE DIAMETER = 168.0 MICROMETERS
 GAS COMPOSITION (PERCENT)          CO2 = 12.88          CO =  0.00          N2 = 73.60          O2 =  5.52          H2O =  8.00
 CALC. MASS LOADING = 3.9892E-01 GR/ACF            6.5325E-01 GR/DNCF             9.1286E+02 MG/ACM             1.4949E+03 MG/DNCM
 IMPACTOR STAGE                               CYC        S0        S1        S2        S3        S4        S5        S6     FILTER
 STAGE INDEX NUMBER                             1         2         3         4         5         6         7         8         9
 D50 (MICROMETERS)                          11.05      6.42      3.56      2.31      1.55      0.54      0.45      0.15
 MASS (MILLIGRAMS)                           8.21      0.75      0.86      0.48      0.84      0.58      0.16      0.00      0.14
 MG/DNCM/STAGE                           1.02E+03  9.33E+01  1.07E+02  5.97E+01  1.04E+02  7.21E+01  1.99E+01  0.00E-01  1.74E+01
 CUM. PERCENT OF MASS SMALLER THAN D50  31.70     25.46     18.30     14.31      7.32      2.50      1.16      1.16
 CUM. (MG/ACM) SMALLER THAN D50          2.89E+02  2.32E+02  1.67E+02  1.31E+02  6.68E+01  2.28E+01  1.06E+01  1.06E+01
 CUM. (MG/DNCM) SMALLER THAN D50         4.74E+02  3.81E+02  2.74E+02  2.14E+02  1.09E+02  3.73E+01  1.74E+01  1.74E+01
 CUM. (GR/ACF) SMALLER THAN D50          1.26E-01  1.02E-01  7.30E-02  5.71E-02  2.92E-02  9.96E-03  4.65E-03  4.65E-03
 CUM. (GR/DNCF) SMALLER THAN D50         2.07E-01  1.66E-01  1.20E-01  9.35E-02  4.78E-02  1.63E-02  7.61E-03  7.61E-03
 GEO. MEAN DIA. (MICROMETERS)            4.31E+01  8.42E+00  4.78E+00  2.87E+00  1.89E+00  9.11E-01  4.93E-01  2.59E-01  1.05E-01
 DM/DLOGD (MG/DNCM)                      8.64E+02  3.96E+02  4.18E+02  3.19E+02  6.00E+02  1.56E+02  2.74E+02  0.00E-01  5.78E+01
 DN/DLOGD (NO. PARTICLES/DNCM)           8.60E+06  5.27E+08  3.04E+09  1.07E+10  7.04E+10  1.65E+11  1.83E+12  0.00E-01  4.01E+13

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
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  COLI-12  1-14 76  1600  SUAI
IMPACTOR FLOWRATE = 0,031 ACFM             IMPACTOR TEMPERATURE =  345,0 F = 173,9 C              SAMPLING DURATION =  15,00 MIN
IMPACTOR PRESSURE DROP = 1,2 IN, OF HG     STACK TEMPERATURE =  345,0 F = 173,9 C
ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM,    STACK PRESSURE = 30,00 IN, OF HG     MAX, PARTICLE DIAMETER = 168,0 MICROMETERS
GAS COMPOSITION (PERCENT)          CO2 = 12,88          CO =  0,00           N2 = 73,60          O2 =  5,52          H2O =  8,00
CALC, MASS LOADING = 8,1609E-01 GR/ACF             1,3448E+00 GR/DNCF               1,8675E+03 MG/ACM             3,0773E+03 MG/DNCM
IMPACTOR STAGE                              CYC        S0        S1        S2        S3        S4        S5        S6      FILTER
STAGE INDEX NUMBER                            1         2         3         4         5         6         7         8         9
D50 (MICROMETERS)                          11,08      6,45      3,66      2,37      1,60      0,70      0,53      0,16
MASS (MILLIGRAMS)                          19,96      1,11      1,06      0,80      0,83      0,44      0,19      0,06      0,14
MG/DNCM/STAGE                            2,50E+03  1,39E+02  1,33E+02  1,00E+02  1,04E+02  5,51E+01  2,38E+01  7,51E+00  1,75E+01
CUM, PERCENT OF MASS SMALLER THAN D50    18,83     14,31     10,00      6,75      3,38      1,59      0,81      0,57
CUM, (MG/ACM) SMALLER THAN D50           3,52E+02  2,67E+02  1,87E+02  1,26E+02  6,30E+01  2,96E+01  1,52E+01  1,06E+01
CUM, (MG/DNCM) SMALLER THAN D50          5,79E+02  4,41E+02  3,08E+02  2,08E+02  1,04E+02  4,88E+01  2,50E+01  1,75E+01
CUM, (GR/ACF) SMALLER THAN D50           1,54E-01  1,17E-01  8,16E-02  5,51E-02  2,75E-02  1,29E-02  6,64E-03  4,65E-03
CUM, (GR/DNCF) SMALLER THAN D50          2,53E-01  1,92E-01  1,35E-01  9,08E-02  4,54E-02  2,13E-02  1,09E-02  7,66E-03
GEO, MEAN DIA, (MICROMETERS)             4,31E+01  8,46E+00  4,86E+00  2,95E+00  1,95E+00  1,06E+00  6,12E-01  2,95E-01  1,15E-01
DM/DLOGD (MG/DNCM)                       2,12E+03  5,92E+02  5,38E+02  5,33E+02  6,09E+02  1,54E+02  1,99E+02  1,46E+01  5,82E+01
DN/DLOGD (NO, PARTICLES/DNCM)            2,10E+07  7,80E+08  3,73E+09  1,66E+10  6,53E+10  1,02E+11  6,91E+11  4,52E+11  3,01E+13


NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,
  COLI-13  1-15-76  1135  RUAI
 IMPACTOR FLOWRATE = 0,033 ACFM             IMPACTOR TEMPERATURE =  315,0 F = 157,2 C             SAMPLING DURATION =  15,00 MIN
 IMPACTOR PRESSURE DROP = 1,4 IN, OF HG      STACK TEMPERATURE =  315,0 F = 157,2 C
 ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM,    STACK PRESSURE = 29,91 IN, OF HG     MAX, PARTICLE DIAMETER = 168,0 MICROMETERS
 GAS COMPOSITION (PERCENT)          CO2 = 12,88          CO =  0,00          N2 = 73,60          O2 =  5,52          H2O =  8,00
 CALC, MASS LOADING = 1,9432E+00 GR/ACF             3,0919E+00 GR/DNCF            4,4468E+03 MG/ACM             7,0754E+03 MG/DNCM
 IMPACTOR STAGE                              CYC       S0        S1        S2        S3        S4        S5        S6      FILTER
 STAGE INDEX NUMBER                            1         2         3         4         5         6         7         8         9
 D50 (MICROMETERS)                          10,58      6,17      3,50      2,27      1,53      0,67      0,51      0,15
 MASS (MILLIGRAMS)                          52,28      2,39      2,52      2,20      1,29      1,15      0,21      0,08      0,21
 MG/DNCM/STAGE                             5,93E+03  2,71E+02  2,86E+02  2,50E+02  1,46E+02  1,31E+02  2,38E+01  9,08E+00  2,38E+01
 CUM, PERCENT OF MASS SMALLER THAN D50     16,12     12,29      8,25      4,72      2,65      0,80      0,47      0,34
 CUM, (MG/ACM) SMALLER THAN D50            7,17E+02  5,46E+02  3,67E+02  2,10E+02  1,18E+02  3,57E+01  2,07E+01  1,50E+01
 CUM, (MG/DNCM) SMALLER THAN D50           1,14E+03  8,70E+02  5,83E+02  3,34E+02  1,87E+02  5,68E+01  3,29E+01  2,38E+01
 CUM, (GR/ACF) SMALLER THAN D50            3,13E-01  2,39E-01  1,60E-01  9,17E-02  5,14E-02  1,56E-02  9,04E-03  6,55E-03
 CUM, (GR/DNCF) SMALLER THAN D50           4,99E-01  3,80E-01  2,55E-01  1,46E-01  8,18E-02  2,48E-02  1,44E-02  1,04E-02
 GEO, MEAN DIA, (MICROMETERS)              4,22E+01  8,08E+00  4,64E+00  2,82E+00  1,86E+00  1,01E+00  5,84E-01  2,80E-01  1,09E-01
 DM/DLOGD (MG/DNCM)                        4,94E+03  1,16E+03  1,16E+03  1,33E+03  8,59E+02  3,64E+02  1,99E+02  1,75E+01  7,92E+01
 DN/DLOGD (NO, PARTICLES/DNCM)             5,25E+07  1,75E+09  9,23E+09  4,74E+10  1,06E+11  2,78E+11  7,94E+11  6,32E+11  4,84E+13

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
```

CARD COLUMN
NUMBERS

```
                     DATA DECK FOR PROGRAM  SPLIN1

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DATA DECK FOR PROGRAM GRAPH

CARD COLUMN NUMBERS

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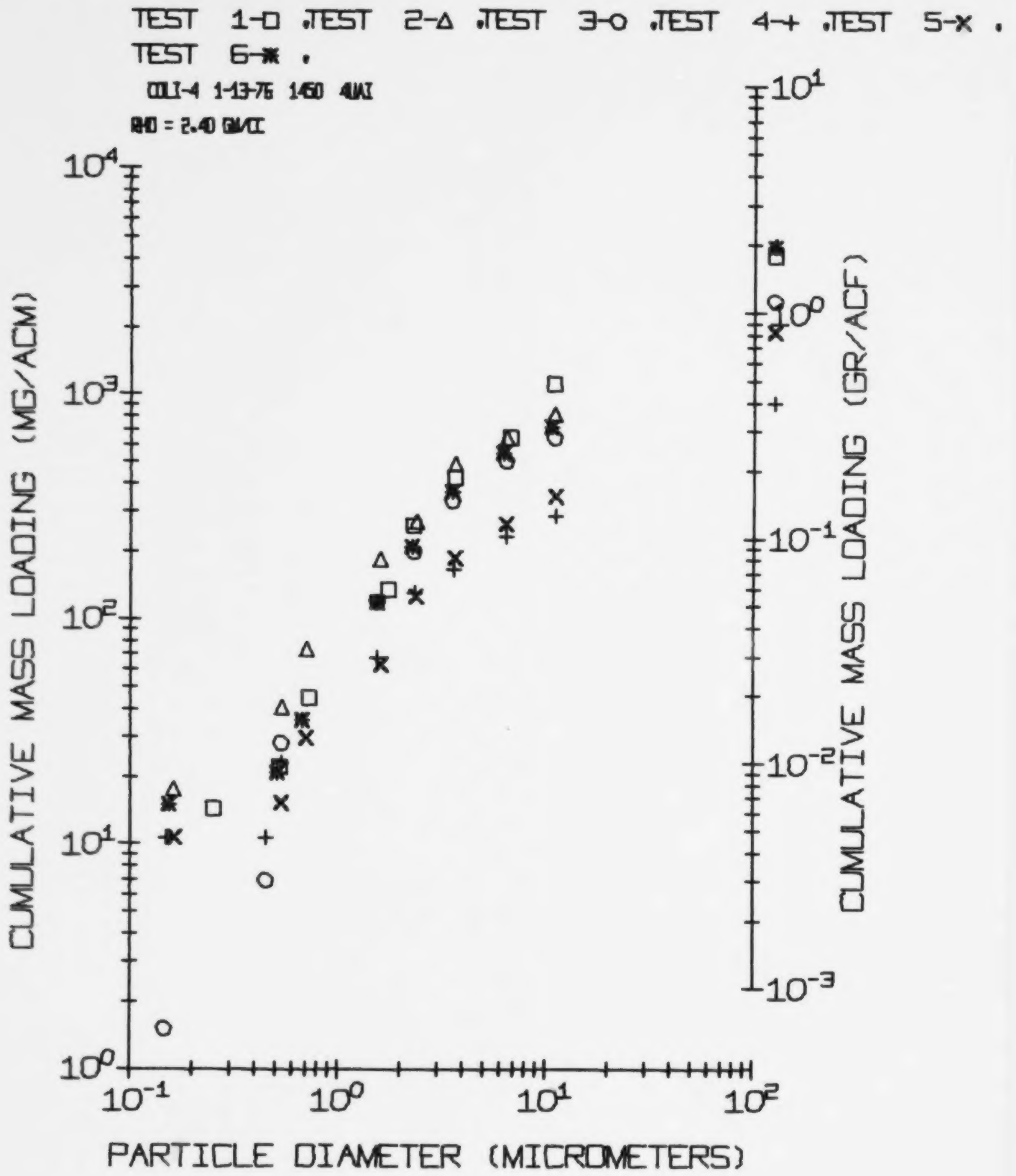

TEST 1-□ .TEST 2-△ .TEST 3-○ .TEST 4-+ .TEST 5-x .
TEST 6-✱ .
COLI-4 1-13-76 1450 4UAI
RHO = 2.40 GM/CC
CUMULATIVE MASS LOADING (MG/ACM)
CUMULATIVE MASS LOADING (GR/ACF)
PARTICLE DIAMETER (MICROMETERS)
10^0
10^1
10^2
10^3
10^4
10^-3
10^-2
10^-1
10^0
10^1
10^-1
10^0
10^1
10^2

```
 COLI-13  1-15-76  1135  BUAT
RHO= 2.40

      INTERVAL                DIAMETER          CUMULATIVE
                              (MICRONS)    PERCENT CONCENTRATION


         5                    2.50E-01            3.72E-01

         6                    2.74E-01            3.81E-01

         7                    2.96E-01            3.89E-01

         8                    3.25E-01            4.02E-01

         9                    3.50E-01            4.14E-01

        10                    3.78E-01            4.29E-01

        11                    4.15E-01            4.52E-01

        12                    4.48E-01            4.77E-01

        13                    4.84E-01            5.07E-01

        14                    5.30E-01            5.55E-01

        15                    5.73E-01            6.12E-01

        16                    6.18E-01            6.86E-01

        17                    6.78E-01            7.89E-01

        18                    7.32E-01            8.86E-01

        19                    8.03E-01            1.02E+00

        20                    8.67E-01            1.14E+00

        21                    9.36E-01            1.28E+00

        22                    1.03E+00            1.47E+00

        23                    1.11E+00            1.65E+00

        24                    1.20E+00            1.85E+00

        25                    1.31E+00            2.12E+00

        26                    1.42E+00            2.37E+00

        27                    1.53E+00            2.66E+00

        28                    1.68E+00            3.05E+00

        29                    1.81E+00            3.41E+00
```

```
30          1.96E+00         3.82E+00
31          2.14E+00         4.36E+00
32          2.32E+00         4.87E+00
33          2.50E+00         5.42E+00
34          2.74E+00         6.14E+00
35          2.96E+00         6.77E+00
36          3.25E+00         7.53E+00
37          3.50E+00         8.15E+00
38          3.78E+00         8.77E+00
39          4.15E+00         9.49E+00
40          4.48E+00         1.01E+01
41          4.84E+00         1.06E+01
42          5.30E+00         1.13E+01
43          5.73E+00         1.18E+01
44          6.18E+00         1.24E+01
45          6.78E+00         1.30E+01
46          7.32E+00         1.35E+01
47          8.03E+00         1.41E+01
48          8.67E+00         1.47E+01
49          9.36E+00         1.52E+01
50          1.03E+01         1.60E+01
51          1.11E+01         1.66E+01
52          1.20E+01         1.74E+01
53          1.31E+01         1.87E+01
54          1.42E+01         1.99E+01
55          1.53E+01         2.14E+01
56          1.68E+01         2.35E+01
57          1.81E+01         2.54E+01
58          1.96E+01         2.75E+01
59          2.14E+01         3.04E+01
```

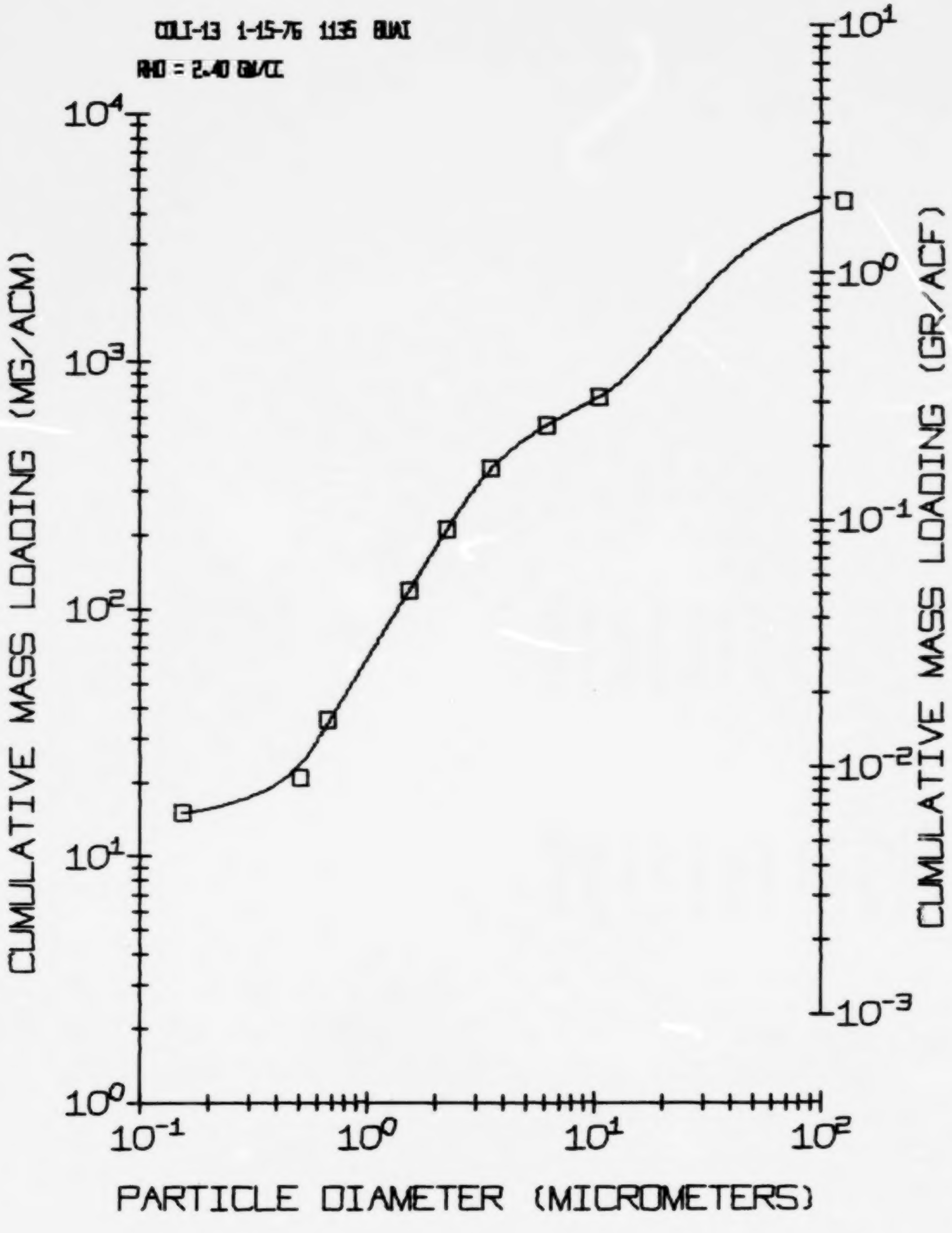
```
60          2,32E+01          3,31E+01
61          2,54E+01          3,64E+01
62          2,74E+01          3,94E+01
63          2,96E+01          4,26E+01
64          3,25E+01          4,66E+01
65          3,50E+01          5,01E+01
66          3,78E+01          5,36E+01
67          4,15E+01          5,78E+01
68          4,48E+01          6,14E+01
69          4,84E+01          6,50E+01
70          5,30E+01          6,92E+01
71          5,73E+01          7,26E+01
72          6,18E+01          7,59E+01
73          6,78E+01          7,97E+01
74          7,32E+01          8,27E+01
75          8,03E+01          8,61E+01
76          8,67E+01          8,87E+01
77          9,36E+01          9,11E+01
```

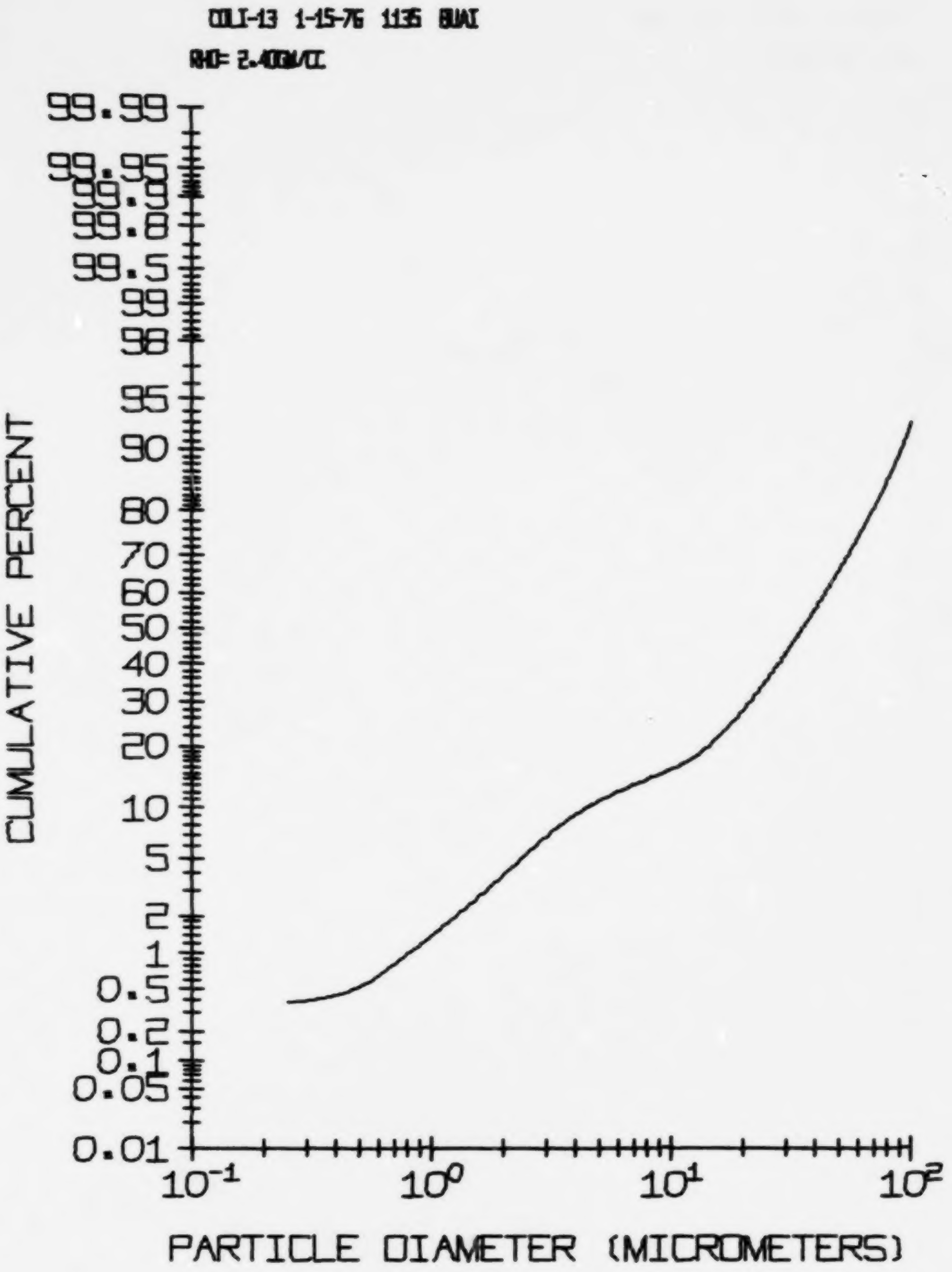
```
COLI-13  1-15-76  1135  BUAI
RHO= 2.40 GM/CC

                                            CHANGE IN
     INTERVAL          DIAMETER         MASS CONCENTRATION
                       (MICRONS)            (MG/DNM3)

         1             2.50E-01             1.55E+01
         2             2.95E-01             1.96E+01
         3             3.47E-01             2.85E+01
         4             4.09E-01             4.46E+01
         5             4.83E-01             7.21E+01
         6             5.69E-01             1.37E+02
         7             6.71E-01             1.92E+02
         8             7.91E-01             2.44E+02
         9             9.32E-01             3.10E+02
        10             1.10E+00             3.94E+02
        11             1.29E+00             5.02E+02
        12             1.53E+00             6.41E+02
        13             1.80E+00             8.06E+02
        14             2.12E+00             1.01E+03
        15             2.50E+00             1.22E+03
        16             2.95E+00             1.34E+03
        17             3.47E+00             1.32E+03
        18             4.09E+00             1.26E+03
        19             4.83E+00             1.20E+03
        20             5.69E+00             1.12E+03
        21             6.71E+00             1.09E+03
        22             7.91E+00             1.13E+03
        23             9.32E+00             1.23E+03
        24             1.10E+01             1.50E+03
        25             1.29E+01             2.35E+03
```

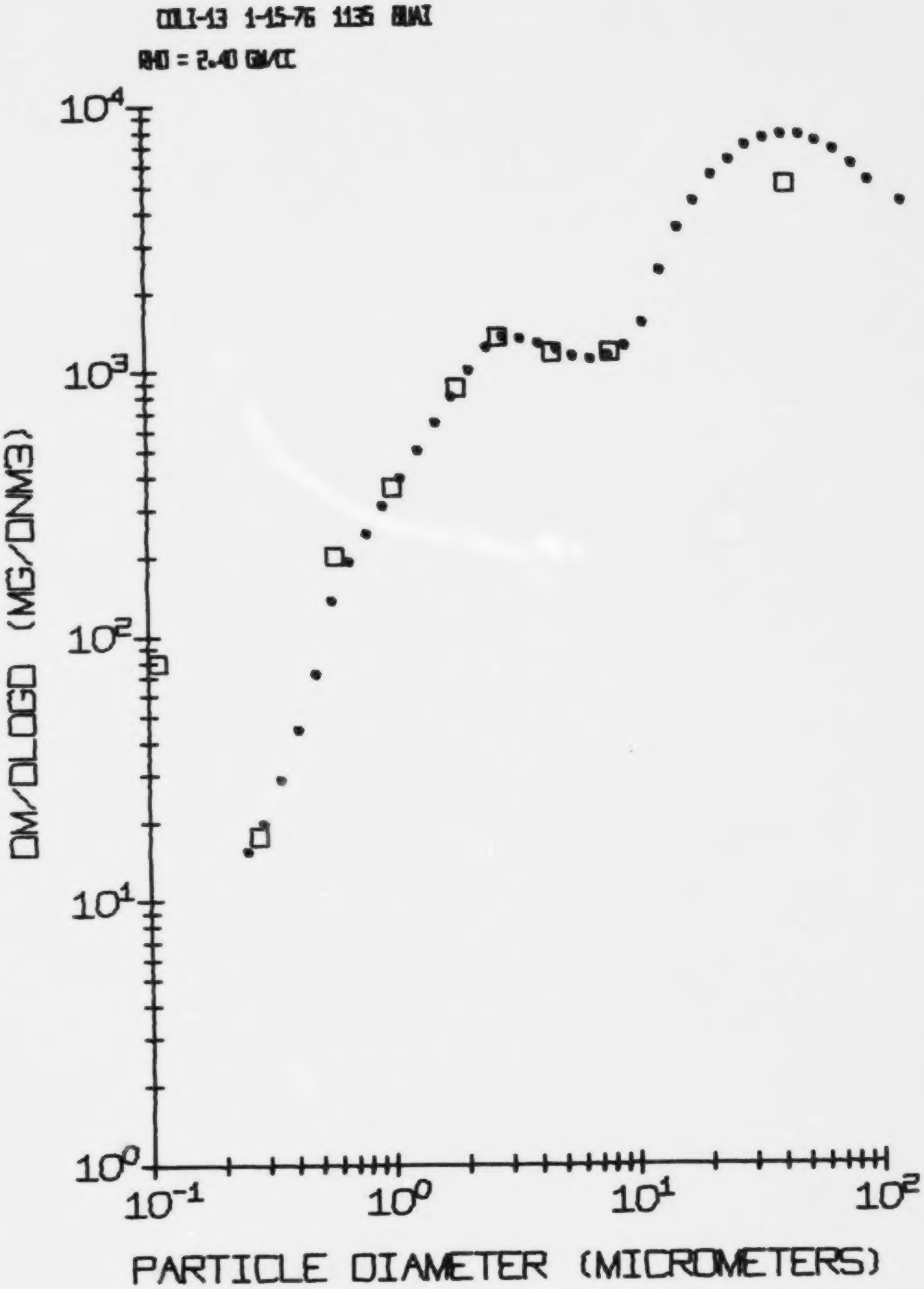
26	1.53E+01	3.42E+03
27	1.80E+01	4.27E+03
28	2.12E+01	5.36E+03
29	2.50E+01	6.12E+03
30	2.95E+01	6.92E+03
31	3.47E+01	7.35E+03
32	4.09E+01	7.59E+03
33	4.83E+01	7.51E+03
34	5.69E+01	7.14E+03
35	6.71E+01	6.59E+03
36	7.91E+01	5.83E+03
37	9.32E+01	5.04E+03
38	1.10E+02	4.20E+03

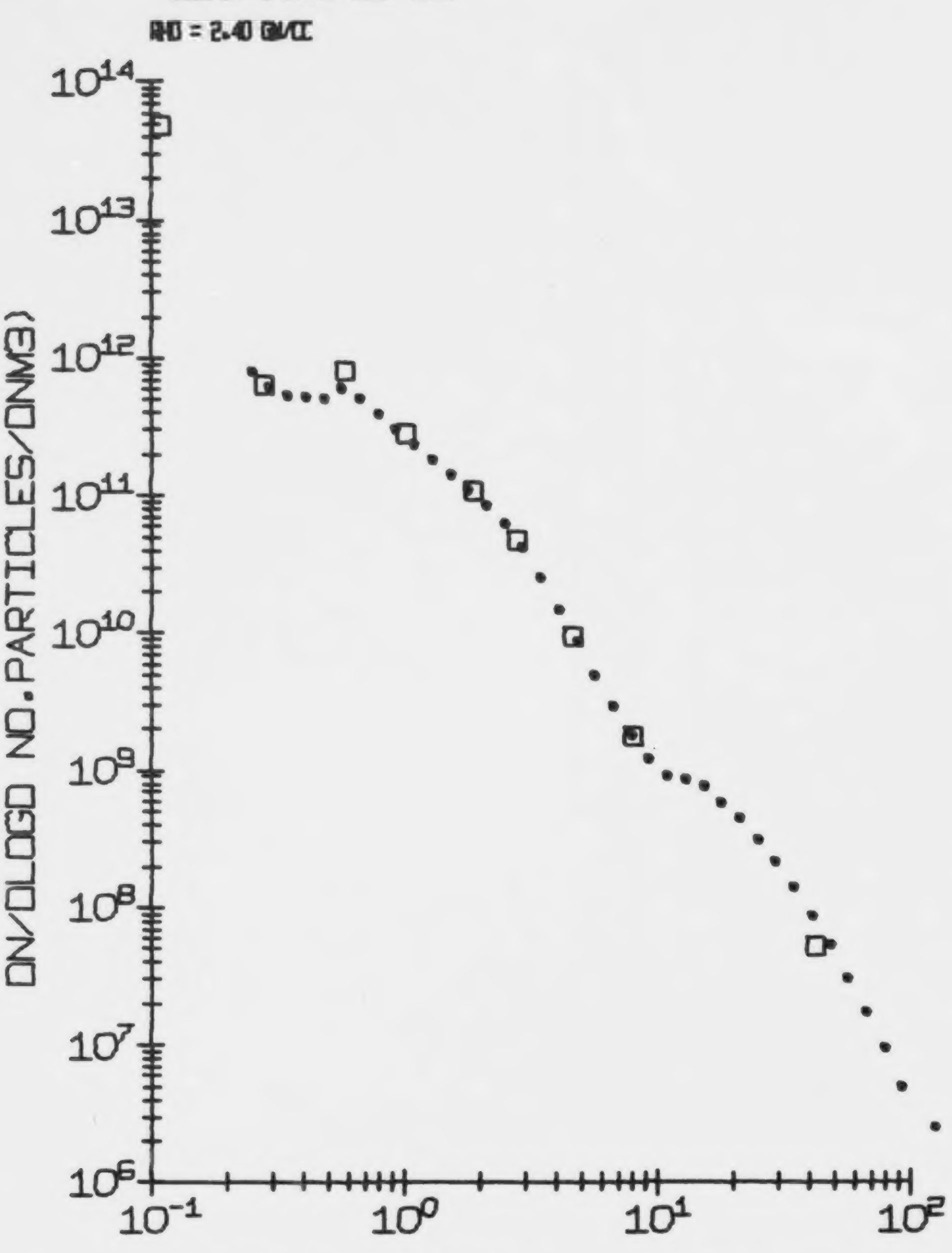
```
COLI-13  1-15-76  1135  AUAT
RHO= 2,40 GM/CC

                                         CHANGE IN
   INTERVAL           DIAMETER     NUMBER CONCENTRATION
                      (MICRONS)         (NO/DNM3)

      1               2,50E-01          7,90E+11
      2               2,95E-01          6,10E+11
      3               3,47E-01          5,42E+11
      4               4,09E-01          5,17E+11
      5               4,83E-01          5,11E+11
      6               5,69E-01          5,92E+11
      7               6,71E-01          5,06E+11
      8               7,91E-01          3,93E+11
      9               9,32E-01          3,05E+11
     10               1,10E+00          2,36E+11
     11               1,29E+00          1,84E+11
     12               1,53E+00          1,43E+11
     13               1,80E+00          1,10E+11
     14               2,12E+00          8,45E+10
     15               2,50E+00          6,22E+10
     16               2,95E+00          4,18E+10
     17               3,47E+00          2,50E+10
     18               4,09E+00          1,46E+10
     19               4,83E+00          8,50E+09
     20               5,69E+00          4,86E+09
     21               6,71E+00          2,88E+09
     22               7,91E+00          1,81E+09
     23               9,32E+00          1,21E+09
     24               1,10E+01          9,03E+08
     25               1,29E+01          8,60E+08
```

```
26          1.53E+01     7.65E+08
27          1.80E+01     5.83E+08
28          2.12E+01     4.47E+08
29          2.50E+01     3.12E+08
30          2.95E+01     2.15E+08
31          3.47E+01     1.40E+08
32          4.09E+01     8.79E+07
33          4.83E+01     5.32E+07
34          5.69E+01     3.08E+07
35          6.71E+01     1.74E+07
36          7.91E+01     9.39E+06
37          9.32E+01     4.95E+06
38          1.10E+02     2.52E+06
```


COLI-13 1-15-76 1135 BUAI
RHO = 2.40 GM/CC
CUMULATIVE MASS LOADING (MG/ACM)
10^4
10^3
10^2
10^1
10^0
CUMULATIVE MASS LOADING (GR/ACF)
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-1}
10^0
10^1
10^2
PARTICLE DIAMETER (MICROMETERS)


COLI-13 1-15-76 1135 BUAI
RHO= 2.40GM/CC
CUMULATIVE PERCENT
99.99
99.95
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
10^{-1}
10^{0}
10^{1}
10^{2}
PARTICLE DIAMETER (MICROMETERS)


COLI-13 1-15-76 1135 BUAI
RHO = 2.40 GM/CC
DM/DLOGD (MG/DNM3)
10^4
10^3
10^2
10^1
10^0
10^{-1}
10^0
10^1
10^2
PARTICLE DIAMETER (MICROMETERS)


COLI-13 1-15-76 1136 BUAI
RHO = 2.40 GM/CC
DN/DLOGD NO.PARTICLES/DNM3)
10^{14}
10^{13}
10^{12}
10^{11}
10^{10}
10^{9}
10^{8}
10^{7}
10^{6}
10^{-1}
10^{0}
10^{1}
10^{2}
PARTICLE DIAMETER (MICROMETERS)

DATA DECK FOR PROGRAM STATIS

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1
1000001111
000.0
21
```

CARD COLUMN
NUMBERS

```
CIDRS VERSION 1 TEST FOR BRINK.
RHO= 2.40 GM/CC

INTERVAL   DIAMETER      MEAN CUMULATIVE     UPPER CONFIDENCE     LOWER CONFIDENCE
           (MICRONS)  MASS CONCENTRATION          LIMIT                 LIMIT
                           (MG/ACM)              (MG/ACM)              (MG/ACM)

    1      2.50E-01        0.00E-01              1.50E-02             -1.50E-02
    2      2.71E-01        3.39E-01              3.69E-01              3.09E-01
    3      2.95E-01        7.16E-01              7.81E-01              6.52E-01
    4      3.20E-01        1.15E+00              1.24E+00              1.06E+00
    5      3.47E-01        1.70E+00              1.81E+00              1.58E+00
    6      3.77E-01        2.42E+00              2.56E+00              2.27E+00
    7      4.09E-01        3.52E+00              3.79E+00              3.24E+00
    8      4.45E-01        5.19E+00              5.60E+00              4.79E+00
    9      4.83E-01        7.68E+00              8.40E+00              6.97E+00
   10      5.24E-01        1.13E+01              1.24E+01              1.02E+01
   11      5.69E-01        1.60E+01              1.74E+01              1.45E+01
   12      6.18E-01        2.17E+01              2.36E+01              1.98E+01
   13      6.71E-01        2.81E+01              3.03E+01              2.59E+01
   14      7.28E-01        3.48E+01              3.73E+01              3.22E+01
   15      7.91E-01        4.17E+01              4.46E+01              3.88E+01
   16      8.58E-01        4.88E+01              5.19E+01              4.57E+01
   17      9.32E-01        5.60E+01              5.93E+01              5.27E+01
   18      1.01E+00        6.33E+01              6.67E+01              5.98E+01
   19      1.10E+00        7.07E+01              7.42E+01              6.71E+01
   20      1.19E+00        7.82E+01              8.19E+01              7.45E+01
   21      1.29E+00        8.61E+01              8.99E+01              8.22E+01
   22      1.41E+00        9.46E+01              9.87E+01              9.05E+01
   23      1.53E+00        1.04E+02              1.08E+02              9.96E+01
   24      1.66E+00        1.15E+02              1.20E+02              1.10E+02
   25      1.80E+00        1.28E+02              1.33E+02              1.22E+02
   26      1.95E+00        1.43E+02              1.49E+02              1.37E+02
   27      2.12E+00        1.61E+02              1.68E+02              1.55E+02
   28      2.30E+00        1.82E+02              1.89E+02              1.75E+02
   29      2.50E+00        2.04E+02              2.11E+02              1.96E+02
   30      2.71E+00        2.27E+02              2.35E+02              2.19F+02
   31      2.95E+00        2.51E+02              2.61E+02              2.42E+02
   32      3.20E+00        2.76E+02              2.85E+02              2.66E+02
   33      3.47E+00        2.99E+02              3.10E+02              2.89E+02
   34      3.77E+00        3.22E+02              3.33E+02              3.12E+02
   35      4.09E+00        3.45E+02              3.56E+02              3.34E+02
   36      4.45E+00        3.66E+02              3.77E+02              3.55E+02
   37      4.83E+00        3.87E+02              3.99E+02              3.76F+02
   38      5.24E+00        4.08E+02              4.20E+02              3.96E+02
   39      5.69E+00        4.29E+02              4.42E+02              4.17E+02
   40      6.18E+00        4.51E+02              4.64E+02              4.38E+02
   41      6.71E+00        4.71E+02              4.84E+02              4.58E+02
   42      7.28E+00        4.88E+02              5.01E+02              4.75E+02
   43      7.91E+00        5.06E+02              5.20E+02              4.93E+02
```

```
CIDRS VERSION 1 TEST FOR BRINK.
RHO= 2.40 GM/CC
INTERVAL   DIAMETER    RECORDS EXCLUDED FROM MEAN
                      CUMULATIVE MASS CONCENTRATION

    1      2.50E-01       3  7
    2      2.71E-01       3  7
    3      2.95E-01       3
    4      3.20E-01       3
    5      3.47E-01       3
    6      3.77E-01       3
    7      4.09E-01     NONE
    8      4.45E-01     NONE
    9      4.83E-01     NONE
   10      5.24E-01     NONE
   11      5.69E-01     NONE
   12      6.18E-01     NONE
   13      6.71E-01     NONE
   14      7.28E-01     NONE
   15      7.91E-01     NONE
   16      8.58E-01     NONE
   17      9.32E-01     NONE
   18      1.01E+00     NONE
   19      1.10E+00     NONE
   20      1.19E+00     NONE
   21      1.29E+00     NONE
   22      1.41E+00     NONE
   23      1.53E+00     NONE
   24      1.66E+00     NONE
   25      1.80E+00     NONE
   26      1.95E+00     NONE
   27      2.12E+00     NONE
   28      2.30E+00     NONE
   29      2.50E+00     NONE
   30      2.71E+00     NONE
   31      2.95E+00     NONE
   32      3.20E+00     NONE
   33      3.47E+00     NONE
   34      3.77E+00     NONE
   35      4.09E+00     NONE
   36      4.45E+00     NONE
   37      4.83E+00     NONE
   38      5.24E+00     NONE
   39      5.69E+00     NONE
   40      6.18E+00     NONE
   41      6.71E+00       1
   42      7.28E+00       1
   43      7.91E+00       1
```

```
CIDRS VERSION 1 TEST FOR BRINK.
RHO= 2.40 GM/CC
                         MEAN CUMULATIVE    UPPER CONFIDENCE    LOWER CONFIDENCE
INTERVAL   DIAMETER   MASS CONCENTRATION        LIMIT               LIMIT
           (MICRONS)       (PERCENT)          (PERCENT)           (PERCENT)
    1      2.50E-01        0.00E-01           4.89E-04           -4.89F-04
    2      2.71E-01        1.10E-02           1.20E-02            1.01E-02
    3      2.95E-01        2.33E-02           2.54E-02            2.12E-02
    4      3.20E-01        3.74E-02           4.03E-02            3.45E-02
    5      3.47E-01        5.52E-02           5.89E-02            5.16E-02
    6      3.77E-01        7.86E-02           8.34E-02            7.39E-02
    7      4.09E-01        1.14E-01           1.23E-01            1.06E-01
    8      4.45E-01        1.69E-01           1.82E-01            1.56F-01
    9      4.83E-01        2.50E-01           2.73E-01            2.27E-01
   10      5.24E-01        3.68E-01           4.03E-01            3.33E-01
   11      5.69E-01        5.20E-01           5.67E-01            4.72E-01
   12      6.18E-01        7.06E-01           7.67E-01            6.46E-01
   13      6.71E-01        9.15E-01           9.88E-01            8.42E-01
   14      7.28E-01        1.13E+00           1.22E+00            1.05E+00
   15      7.91E-01        1.36E+00           1.45E+00            1.26E+00
   16      8.58E-01        1.59E+00           1.69E+00            1.49E+00
   17      9.32E-01        1.82E+00           1.93E+00            1.71E+00
   18      1.01E+00        2.06E+00           2.17E+00            1.95E+00
   19      1.10E+00        2.30E+00           2.42E+00            2.18E+00
   20      1.19E+00        2.55E+00           2.67E+00            2.43E+00
   21      1.29E+00        2.80E+00           2.93E+00            2.68E+00
   22      1.41E+00        3.08E+00           3.21E+00            2.95E+00
   23      1.53E+00        3.39E+00           3.53E+00            3.24E+00
   24      1.66E+00        3.74E+00           3.89E+00            3.58E+00
   25      1.80E+00        4.16E+00           4.33E+00            3.99E+00
   26      1.95E+00        4.66E+00           4.85E+00            4.48E+00
   27      2.12E+00        5.26E+00           5.46E+00            5.05E+00
   28      2.30E+00        5.92E+00           6.15E+00            5.69E+00
   29      2.50E+00        6.64E+00           6.88E+00            6.39E+00
   30      2.71E+00        7.40E+00           7.67E+00            7.13E+00
   31      2.95E+00        8.19E+00           8.48E+00            7.89E+00
   32      3.20E+00        8.98E+00           9.29E+00            8.67E+00
   33      3.47E+00        9.75E+00           1.01E+01            9.42E+00
   34      3.77E+00        1.05E+01           1.08E+01            1.02E+01
   35      4.09E+00        1.12E+01           1.16E+01            1.09E+01
   36      4.45E+00        1.19E+01           1.23E+01            1.16E+01
   37      4.83E+00        1.26E+01           1.30E+01            1.22E+01
   38      5.24E+00        1.33E+01           1.37E+01            1.29E+01
   39      5.69E+00        1.40E+01           1.44E+01            1.36E+01
   40      6.18E+00        1.47E+01           1.51E+01            1.43E+01
   41      6.71E+00        1.53E+01           1.57E+01            1.49F+01
   42      7.28E+00        1.59E+01           1.63E+01            1.55E+01
   43      7.91E+00        1.65E+01           1.69E+01            1.60E+01
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CIDRS VERSION 1 TEST FOR BRINK.
RHO= 2.40 GM/CC

                                 MEAN CHANGE           STANDARD    UPPER CONFIDENCE   LOWER CONFIDENCE
INTERVAL   DIAMETER    IN MASS CONCENTRATION   DEVIATION         LIMIT               LIMIT
                                  (MG/DNM3)            (MG/DNM3)       (MG/DNM3)          (MG/DNM3)
    1      2.50E-01               1.42E+01             1.63E+00        1.48E+01           1.36E+01
    2      2.95E-01               1.76E+01             7.82E+00        2.02E+01           1.50E+01
    3      3.47E-01               2.81E+01             9.48E+00        3.13E+01           2.49E+01
    4      4.09E-01               6.62E+01             3.55E+01        7.68E+01           5.57E+01
    5      4.83E-01               1.46E+02             9.15E+01        1.73E+02           1.19E+02
    6      5.69E-01               2.40E+02             1.53E+02        2.86E+02           1.95E+02
    7      6.71E-01               3.00E+02             1.92E+02        3.57E+02           2.43E+02
    8      7.91E-01               3.24E+02             2.00E+02        3.83E+02           2.64E+02
    9      9.32E-01               3.30E+02             1.66E+02        3.80E+02           2.80E+02
   10      1.10E+00               3.41E+02             1.37E+02        3.81E+02           3.00E+02
   11      1.29E+00               3.73E+02             1.68E+02        4.23E+02           3.23E+02
   12      1.53E+00               4.52E+02             2.53E+02        5.28E+02           3.77E+02
   13      1.80E+00               6.49E+02             3.21E+02        7.45E+02           5.53E+02
   14      2.12E+00               8.89E+02             4.10E+02        1.01E+03           7.67E+02
   15      2.50E+00               1.04E+03             4.64E+02        1.18E+03           9.04E+02
   16      2.95E+00               1.13E+03             5.49E+02        1.29E+03           9.62E+02
   17      3.47E+00               1.07E+03             4.94E+02        1.21E+03           9.18E+02
   18      4.09E+00               9.96E+02             4.21E+02        1.12E+03           8.70E+02
   19      4.83E+00               9.59E+02             3.87E+02        1.07E+03           8.44E+02
   20      5.69E+00               9.72E+02             4.61E+02        1.11E+03           8.35E+02
   21      6.71E+00               8.05E+02             3.14E+02        9.09E+02           7.00E+02
   22      7.91E+00               8.29E+02             3.29E+02        9.39E+02           7.19E+02
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CIDRS VERSION 1 TEST FOR BRINK.
RHO= 2.40 GM/CC
INTERVAL   DIAMETER    RECORDS EXCLUDED FROM MEAN
                      CHANGE IN MASS CONTRATION

    1      2.50E-01       3  7
    2      2.95E-01       3
    3      3.47E-01       3
    4      4.09E-01      NONE
    5      4.83E-01      NONE
    6      5.69E-01      NONE
    7      6.71E-01      NONE
    8      7.91E-01      NONE
    9      9.32E-01      NONE
   10      1.10E+00      NONE
   11      1.29E+00      NONE
   12      1.53E+00      NONE
   13      1.80E+00      NONE
   14      2.12E+00      NONE
   15      2.50E+00      NONE
   16      2.95E+00      NONE
   17      3.47E+00      NONE
   18      4.09E+00      NONE
   19      4.83E+00      NONE
   20      5.69E+00      NONE
   21      6.71E+00       1
   22      7.91E+00       1
```

```
CIDRS VERSION 1 TEST FOR BRINK.
RHO= 2.40 GM/CC
                                    MEAN CHANGE             STANDARD    UPPER CONFIDENCE    LOWER CONFIDENCE
INTERVAL    DIAMETER      IN NUMBER CONCENTRATION        DEVIATION         LIMIT               LIMIT
                                    (NO/DNM3)               (NO/DNM3)        (NO/DNM3)           (NO/DNM3)
    1        2.50E-01               7.23E+11                8.29E+10         7.55E+11            6.91E+11
    2        2.95E-01               5.48E+11                2.43E+11         6.29E+11            4.67E+11
    3        3.47E-01               5.34E+11                1.80E+11         5.94E+11            4.74E+11
    4        4.09E-01               7.68E+11                4.11E+11         8.91E+11            6.45E+11
    5        4.83E-01               1.03E+12                6.48E+11         1.23E+12            8.39E+11
    6        5.69E-01               1.04E+12                6.62E+11         1.24E+12            8.41E+11
    7        6.71E-01               7.92E+11                5.06E+11         9.43E+11            6.41E+11
    8        7.91E-01               5.21E+11                3.22E+11         6.17E+11            4.25E+11
    9        9.32E-01               3.25E+11                1.64E+11         3.73E+11            2.76E+11
   10        1.10E+00               2.04E+11                8.22E+10         2.29E+11            1.80E+11
   11        1.29E+00               1.37E+11                6.16E+10         1.55E+11            1.18E+11
   12        1.53E+00               1.01E+11                5.65E+10         1.18E+11            8.44E+10
   13        1.80E+00               8.87E+10                4.39E+10         1.02E+11            7.56E+10
   14        2.12E+00               7.42E+10                3.42E+10         8.44E+10            6.40E+10
   15        2.50E+00               5.31E+10                2.36E+10         6.01E+10            4.60E+10
   16        2.95E+00               3.50E+10                1.71E+10         4.01E+10            2.99E+10
   17        3.47E+00               2.02E+10                9.38E+09         2.30E+10            1.74E+10
   18        4.09E+00               1.15E+10                4.87E+09         1.30E+10            1.01E+10
   19        4.83E+00               6.79E+09                2.74E+09         7.61E+09            5.97E+09
   20        5.69E+00               4.20E+09                1.99E+09         4.80E+09            3.61E+09
   21        6.71E+00               2.12E+09                8.29E+08         2.40E+09            1.85E+09
   22        7.91E+00               1.34E+09                5.30E+08         1.51E+09            1.16E+09
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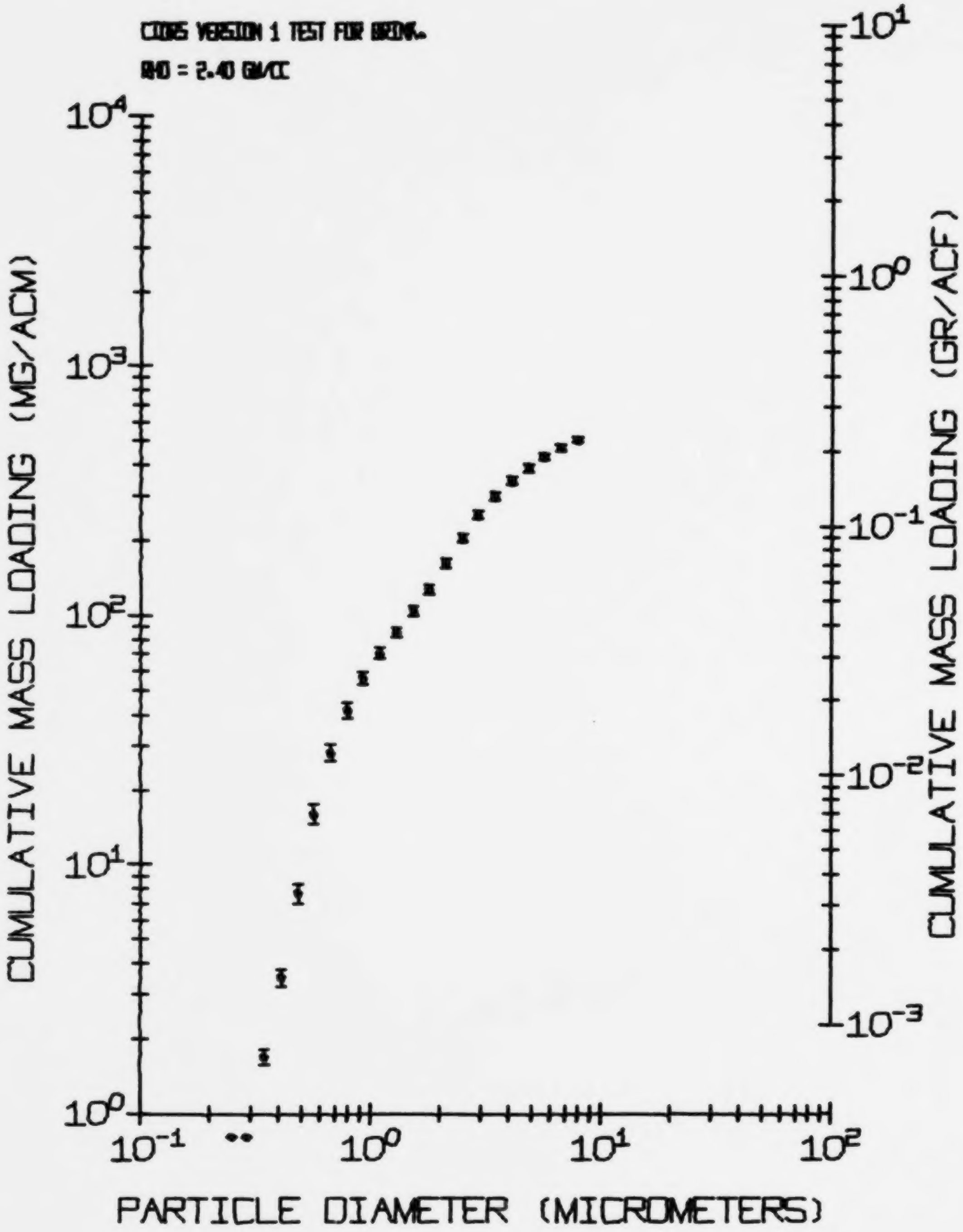
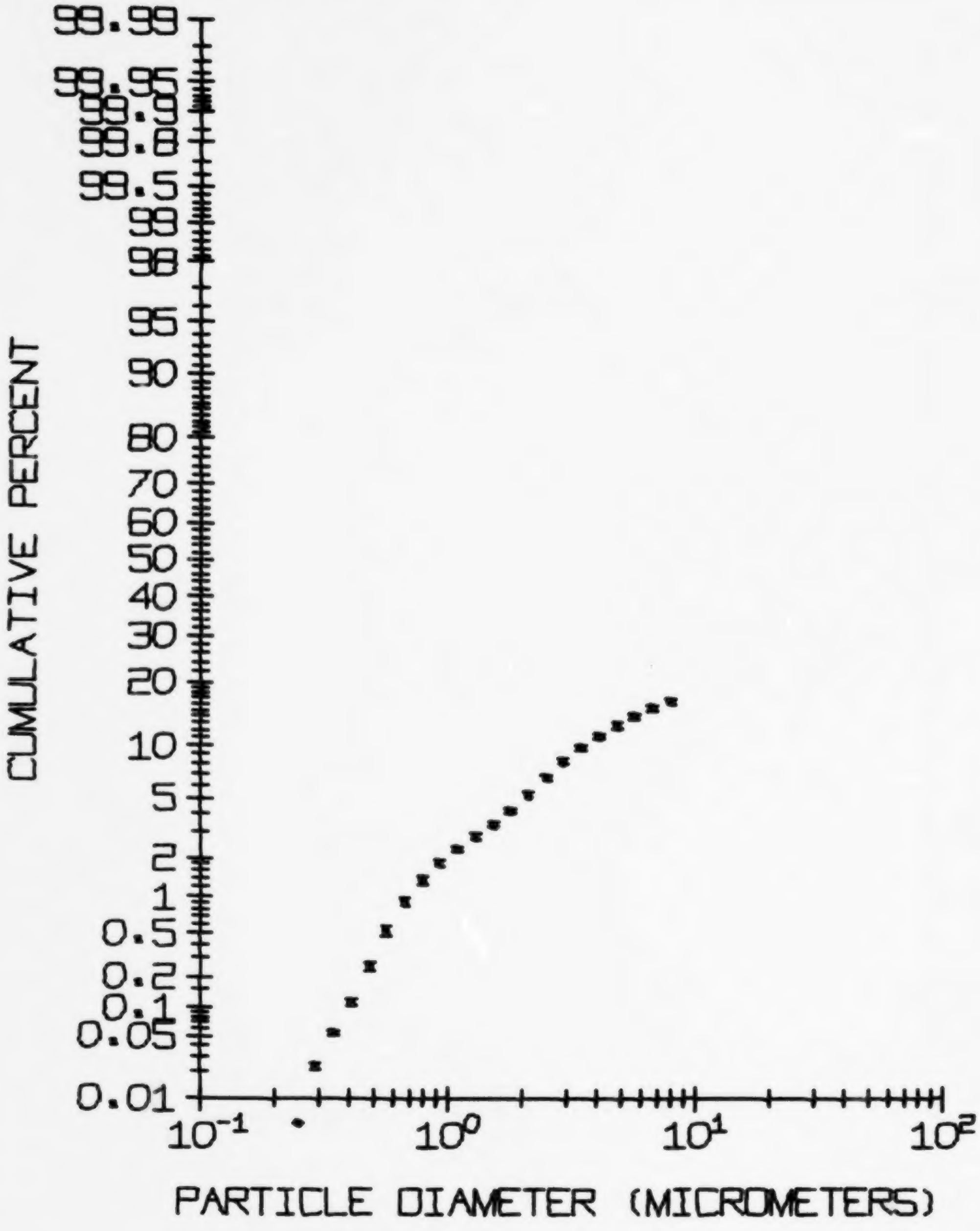
CIDRS VERSION 1 TEST FOR BRINK.
RHO= 2.40 GM/CC
INTERVAL   DIAMETER    RECORDS EXCLUDED FROM MEAN
                       CHANGE IN NUMBER CONCENTRATION

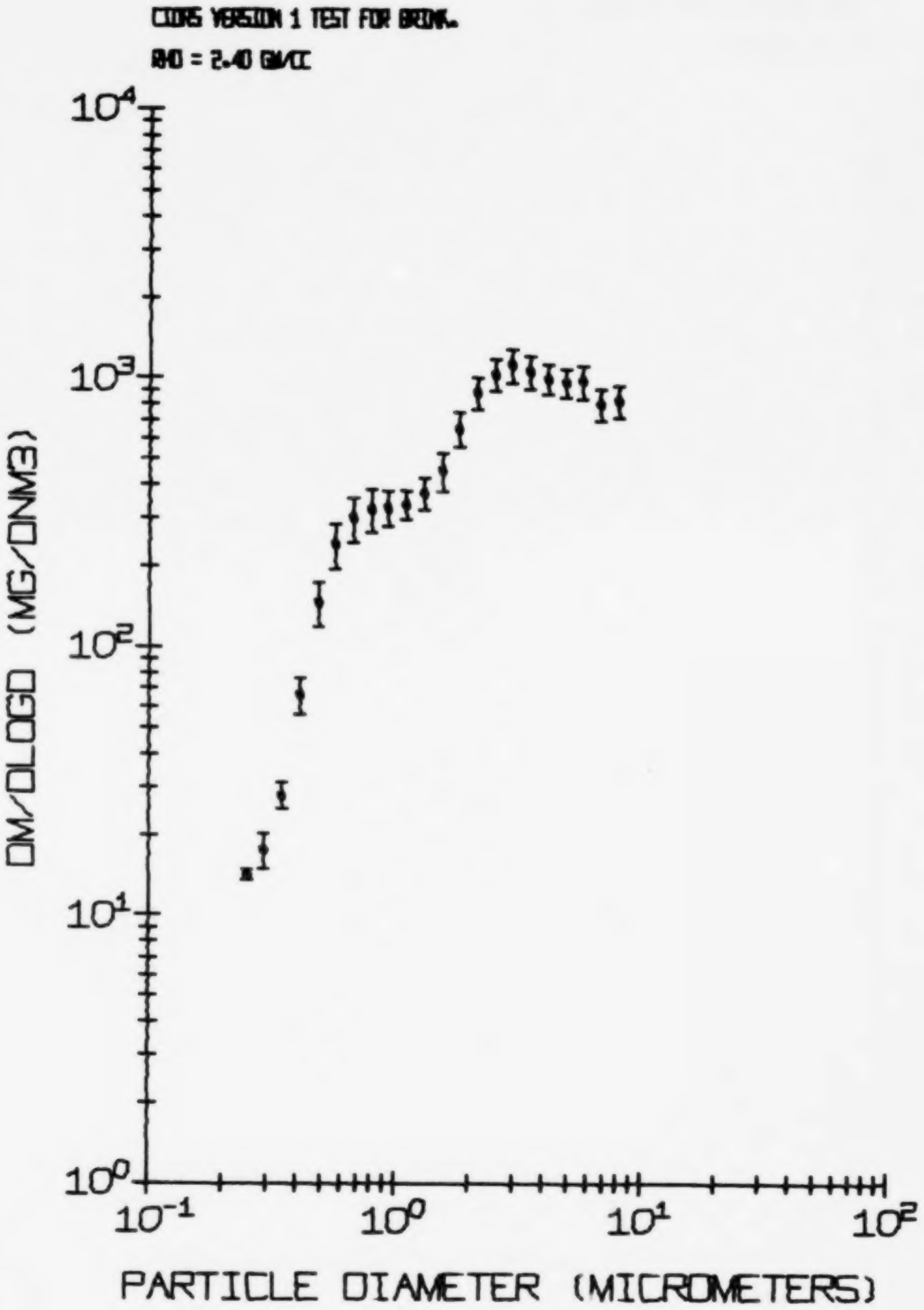
    1       2.50E-01       3  7
    2       2.95E-01       3
    3       3.47E-01       3
    4       4,09E-01      NONE
    5       4.83E-01      NONE
    6       5.69E-01      NONE
    7       6.71E-01      NONE
    8       7.91E-01      NONE
    9       9.32E-01      NONE
   10       1.10E+00      NONE
   11       1.29E+00      NONE
   12       1.53E+00      NONE
   13       1.80E+00      NONE
   14       2.12E+00      NONE
   15       2.50E+00      NONE
   16       2.95E+00      NONE
   17       3.47E+00      NONE
   18       4.09E+00      NONE
   19       4.83E+00      NONE
   20       5.69E+00      NONE
   21       6.71E+00       1
   22       7.91E+00       1
STOP  000000
```

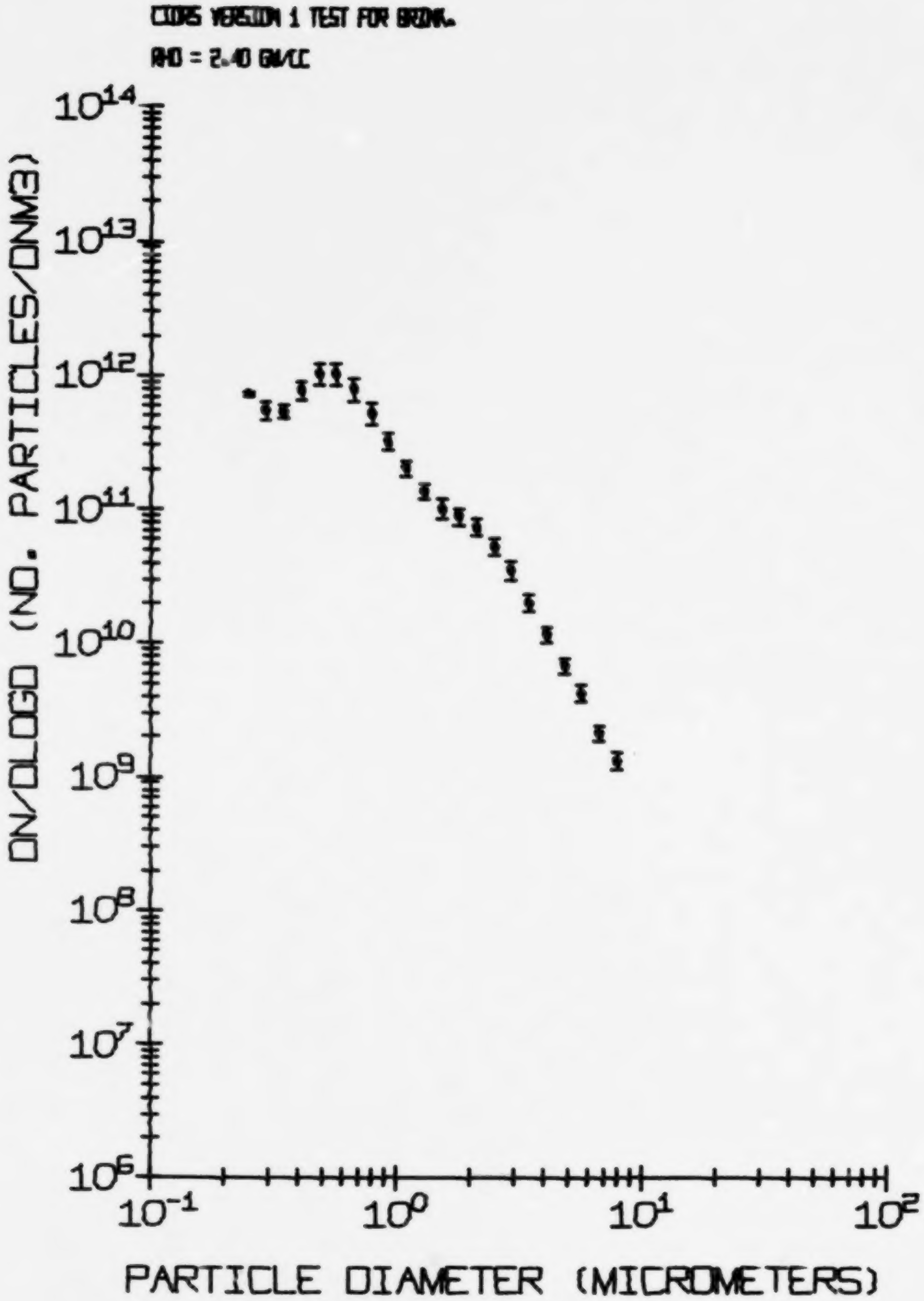

CIDRS VERSION 1 TEST FOR BRINK.
RHO = 2.40 GM/CC
CUMULATIVE MASS LOADING (MG/ACM)
10^4
10^3
10^2
10^1
10^0
CUMULATIVE MASS LOADING (GR/ACF)
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-1}
10^0
10^1
10^2
PARTICLE DIAMETER (MICROMETERS)

CIDRS VERSION 1 TEST FOR BRINK.

RHO= 2.40GM/CC




CIDRS VERSION 1 TEST FOR BRINK.
RHO = 2.40 GM/CC
DM/DLOGD (MG/DNM3)
10^4
10^3
10^2
10^1
10^0
10^{-1}
10^0
10^1
10^2
PARTICLE DIAMETER (MICROMETERS)


CIDRS VERSION 1 TEST FOR BRINK.
RHO = 2.40 GM/CC
DN/DLOGD (NO. PARTICLES/DNM3)
10^{14}
10^{13}
10^{12}
10^{11}
10^{10}
10^{9}
10^{8}
10^{7}
10^{6}
10^{-1}
10^{0}
10^{1}
10^{2}
PARTICLE DIAMETER (MICROMETERS)

DATA DECK FOR PROGRAM MPPROG

CARD COLUMN
NUMBERS

```
          11111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
--------------------------------------------------------------------------------
0100
CIDRS VERSION 1 TEST FOR ANDERSEN.
03
29.42 280.0 280.02.40120.  50.     1
 .14   .00   .80   .06   .08
 0.58  0.37  1.82  3.13  1.60  1.69  2.57  2.87  5.50
 .401
1COLO-19 1-13-76 1630 PORTS 1,2,3
02
29.45 300.0 300.02.40 90.  50.     1
 .14   .00   .80   .06   .08
 2.31  1.24  2.81  4.73  2.97  3.79  3.19  2.83  4.13
 .415
1COLO-31 1-16-76 1336 PORTS 4,5,6
04
30.06 285.0 285.02.40 84.  50.     1
 .14   .00   .80   .06   .08
 1.08  2.01  3.52  5.73  3.27  2.61  2.95  2.32  5.40
 .396
1COLO-37 1-19-76 1544 PORTS 4,5,6
04
30.00 280.0 280.02.40120.  50.     1
 .14   .00   .80   .06   .08
 0.22  0.73  1.89  2.82  1.91  1.92  1.68  1.23  2.48
 .410
1COLO-39 1-20-76 0943 PORTS 1,2,3
05
30.00 280.0 280.02.40120.  50.     1
 .14   .00   .80   .06   .08
 0.00  0.07  1.52  2.71  2.33  2.48  2.18  2.16  3.08
 .381
1COLO-40 1-20-76 0945 PORTS 4,5,6
00
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1COLO-19 1-13-76 1630 PORTS 1,2,3
IMPACTOR FLOWRATE = 0.401 ACFM                 IMPACTOR TEMPERATURE =  280.0 F = 137.8 C            SAMPLING DURATION = 120.00 MIN
IMPACTOR PRESSURE DROP = 0.2 IN. OF HG         STACK TEMPERATURE =  280.0 F = 137.8 C
ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.       STACK PRESSURE = 29.42 IN. OF HG     MAX. PARTICLE DIAMETER =  50.0 MICROMETERS
GAS COMPOSITION (PERCENT)          CO2 = 12.88          CO =  0.00            N2 = 73.60           O2 =  5.52           H2O =  8.00
CALC. MASS LOADING = 6.4558E-03 GR/ACF               9.9711E-03 GR/DNCF              1.4773E+01 MG/ACM               2.2817E+01 MG/DNCM
IMPACTOR STAGE                                S1         S2         S3         S4         S5         S6         S7         S8      FILTER
STAGE INDEX NUMBER                            1          2          3          4          5          6          7          8          9
D50 (MICROMETERS)                           8.65       8.18       4.96       3.42       1.73       0.81       0.51       0.25
MASS (MILLIGRAMS)                           5.50       2.87       2.57       1.69       1.60       3.13       1.82       0.37       0.58
MG/DNCM/STAGE                             6.23E+00   3.25E+00   2.91E+00   1.92E+00   1.81E+00   3.55E+00   2.06E+00   4.19E-01   6.57E-01
CUM. PERCENT OF MASS SMALLER THAN D50   72.68      58.42      45.65      37.26      29.31      13.76      4.72       2.88
CUM. (MG/ACM) SMALLER THAN D50            1.07E+01   8.63E+00   6.74E+00   5.50E+00   4.33E+00   2.03E+00   6.97E-01   4.26E-01
CUM. (MG/DNCM) SMALLER THAN D50           1.66E+01   1.33E+01   1.04E+01   8.50E+00   6.69E+00   3.14E+00   1.08E+00   6.57E-01
CUM. (GR/ACF) SMALLER THAN D50            4.69E-03   3.77E-03   2.95E-03   2.41E-03   1.89E-03   8.88E-04   3.05E-04   1.86E-04
CUM. (GR/DNCF) SMALLER THAN D50           7.25E-03   5.83E-03   4.55E-03   3.72E-03   2.92E-03   1.37E-03   4.71E-04   2.87E-04
GEO. MEAN DIA. (MICROMETERS)              2.08E+01   8.41E+00   6.37E+00   4.12E+00   2.43E+00   1.18E+00   6.41E-01   3.57E-01   1.78E-01
DM/DLOGD (MG/DNCM)                        8.18E+00   1.34E+02   1.34E+01   1.18E+01   6.11E+00   1.08E+01   1.02E+01   1.37E+00   2.18E+00
DN/DLOGD (NO. PARTICLES/DNCM)             7.24E+05   1.79E+08   4.12E+07   1.35E+08   3.40E+08   5.20E+09   3.10E+10   2.39E+10   3.11E+11

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
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1COLO-31 1-16-76 1336 PORTS 4,5,6

IMPACTOR FLOWRATE = 0,415 ACFM                IMPACTOR TEMPERATURE =  300,0 F = 148,9 C            SAMPLING DURATION =  90,00 MIN

IMPACTOR PRESSURE DROP = 0,3 IN, OF HG        STACK TEMPERATURE =  300,0 F = 148,9 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM,      STACK PRESSURE = 29,45 IN, OF HG     MAX, PARTICLE DIAMETER =  50,0 MICROMETERS

GAS COMPOSITION (PERCENT)          CO2 = 12,88          CO =  0,00          N2 = 73,60          O2 =  5,32          H2O =  8,00

CALC, MASS LOADING = 1,1569E-02 GR/ACF             1,8333E-02 GR/DNCF             2,6474E+01 MG/ACM             4,1953E+01 MG/DNCM

IMPACTOR STAGE                              S1        S2        S3        S4        S5        S6        S7        S8      FILTER

STAGE INDEX NUMBER                           1         2         3         4         5         6         7         8         9

D50 (MICROMETERS)                          8,29      7,85      4,89      3,18      1,77      0,82      0,51      0,26

MASS (MILLIGRAMS)                          4,13      2,83      3,19      3,79      2,97      4,73      2,81      1,24      2,31

MG/DNCM/STAGE                          6,19E+00  4,24E+00  4,78E+00  5,68E+00  4,45E+00  7,09E+00  4,21E+00  1,86E+00  3,46E+00

CUM, PERCENT OF MASS SMALLER THAN D50  85,25     75,14     63,75     50,21     39,61     22.71     12,68      8,25

CUM, (MG/ACM) SMALLER THAN D50         2,26E+01  1,99E+01  1,69E+01  1,33E+01  1,05E+01  6,01E+00  3,36E+00  2,18E+00

CUM, (MG/DNCM) SMALLER THAN D50        3,58E+01  3,15E+01  2,67E+01  2,11E+01  1,66E+01  9,53E+00  5,32E+00  3,46E+00

CUM, (GR/ACF) SMALLER THAN D50         9,86E-03  8,69E-03  7,38E-03  5,81E-03  4,58E-03  2,63E-03  1,47E-03  9,54E-04

CUM, (GR/DNCF) SMALLER THAN D50        1,56E-02  1,38E-02  1,17E-02  9,21E-03  7,26E-03  4,16E-03  2,32E-03  1,51E-03

GEO, MEAN DIA, (MICROMETERS)           2,04E+01  8,07E+00  6,20E+00  3,95E+00  2,37E+00  1,20E+00  6,43E-01  3,64E-01  1,85E-01

DM/DLOGD (MG/DNCM)                     7,93E+00  1,82E+02  2,33E+01  3,04E+01  1,75E+01  2,11E+01  2,04E+01  6,45E+00  1,15E+01

DN/DLOGD (NO, PARTICLES/DNCM)          7,48E+05  2,76E+08  7,77E+07  3,94E+08  1,04E+09  9,67E+09  6,10E+10  1,06E+11  1,45E+12


NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,
1COLO-37 1-19-76 1544 PORTS 4,5,6
IMPACTOR FLOWRATE = 0.396 ACFM             IMPACTOR TEMPERATURE =  285.0 F = 140.6 C             SAMPLING DURATION =  84.00 MIN
IMPACTOR PRESSURE DROP = 0.2 IN. OF HG     STACK TEMPERATURE =  285.0 F = 140.6 C
ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.    STACK PRESSURE = 30.06 IN. OF HG    MAX. PARTICLE DIAMETER =  50.0 MICROMETERS
GAS COMPOSITION (PERCENT)        CO2 = 12.88          CO =  0.00           N2 = 73.60          O2 =  5.52           H2O =  8.00
CALC. MASS LOADING = 1.3403E-02 GR/ACF            2.0398E-02 GR/DNCF              3.0671E+01 MG/ACM              4.6677E+01 MG/DNCM
IMPACTOR STAGE                            S1        S2        S3        S4        S5        S6        S7        S8      FILTER
STAGE INDEX NUMBER                         1         2         3         4         5         6         7         8         9
D50 (MICROMETERS)                        8.34      8.08      4.95      3.29      1.92      0.94      0.51      0.24
MASS (MILLIGRAMS)                        5.40      2.32      2.95      2.61      3.27      5.73      3.52      2.01      1.08
MG/DNCM/STAGE                          8.72E+00  3.75E+00  4.77E+00  4.22E+00  5.28E+00  9.26E+00  5.69E+00  3.25E+00  1.74E+00
CUM. PERCENT OF MASS SMALLER THAN D50  81.31     73.28     63.07     54.03     42.71     22.88     10.70     3.74
CUM. (MG/ACM) SMALLER THAN D50         2.49E+01  2.25E+01  1.93E+01  1.66E+01  1.31E+01  7.02E+00  3.28E+00  1.15E+00
CUM. (MG/DNCM) SMALLER THAN D50        3.80E+01  3.42E+01  2.94E+01  2.52E+01  1.99E+01  1.07E+01  4.99E+00  1.74E+00
CUM. (GR/ACF) SMALLER THAN D50         1.09E-02  9.82E-03  8.45E-03  7.24E-03  5.72E-03  3.07E-03  1.43E-03  5.01E-04
CUM. (GR/DNCF) SMALLER THAN D50        1.66E-02  1.49E-02  1.29E-02  1.10E-02  8.71E-03  4.67E-03  2.18E-03  7.63E-04
GEO. MEAN DIA. (MICROMETERS)           2.04E+01  8.21E+00  6.33E+00  4.04E+00  2.52E+00  1.35E+00  6.96E-01  3.49E-01  1.67E-01
DM/DLOGD (MG/DNCM)                     1.12E+01  2.76E+02  2.24E+01  2.38E+01  2.26E+01  2.99E+01  2.16E+01  9.64E+00  5.80E+00
DN/DLOGD (NO. PARTICLES/DNCM)          1.05E+06  3.97E+08  7.04E+07  2.87E+08  1.13E+09  9.73E+09  5.08E+10  1.81E+11  9.86E+11


NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
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ICOLO-39 1-20-76 0943 PORTS 1,2,3
IMPACTOR FLOWRATE = 0.410 ACFM              IMPACTOR TEMPERATURE =  280.0 F = 137.8 C             SAMPLING DURATION = 120.00 MIN
IMPACTOR PRESSURE DROP = 0.3 IN. OF HG      STACK TEMPERATURE =  280.0 F = 137.8 C
ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.    STACK PRESSURE = 30.00 IN. OF HG     MAX. PARTICLE DIAMETER =  50.0 MICROMETERS
GAS COMPOSITION (PERCENT)          CO2 = 12.88          CO =  0.00          N2 = 73.60          O2 =  5.52          H2O =  8.00
CALC. MASS LOADING = 4.6674E-03 GR/ACF              7.0694E-03 GR/DNCF              1.0681E+01 MG/ACM              1.6177E+01 MG/DNCM
IMPACTOR STAGE                         S1        S2        S3        S4        S5        S6        S7        S8      FILTER
STAGE INDEX NUMBER                      1         2         3         4         5         6         7         8         9
D50 (MICROMETERS)                    8.17      7.92      4.85      3.23      1.89      0.92      0.50      0.23
MASS (MILLIGRAMS)                    2.48      1.23      1.68      1.92      1.91      2.82      1.89      0.73      0.22
MG/DNCM/STAGE                    2.70E+00  1.34E+00  1.83E+00  2.09E+00  2.08E+00  3.07E+00  2.05E+00  7.94E-01  2.39E-01
CUM. PERCENT OF MASS SMALLER THAN D50  83.33     75.07     63.78     50.87     38.04     19.09      6.38      1.48
CUM. (MG/ACM) SMALLER THAN D50   8.90E+00  8.02E+00  6.81E+00  5.43E+00  4.06E+00  2.04E+00  6.82E-01  1.58E-01
CUM. (MG/DNCM) SMALLER THAN D50  1.35E+01  1.21E+01  1.03E+01  8.23E+00  6.15E+00  3.09E+00  1.03E+00  2.39E-01
CUM. (GR/ACF) SMALLER THAN D50   3.89E-03  3.50E-03  2.98E-03  2.37E-03  1.78E-03  8.91E-04  2.98E-04  6.90E-05
CUM. (GR/DNCF) SMALLER THAN D50  5.89E-03  5.31E-03  4.51E-03  3.60E-03  2.69E-03  1.35E-03  4.51E-04  1.05E-04
GEO. MEAN DIA. (MICROMETERS)     2.02E+01  8.05E+00  6.20E+00  3.96E+00  2.47E+00  1.32E+00  6.81E-01  3.40E-01  1.63E-01
DM/DLOGD (MG/DNCM)               3.43E+00  9.84E+01  8.59E+00  1.18E+01  8.89E+00  9.89E+00  7.77E+00  2.34E+00  7.95E-01
DN/DLOGD (NO. PARTICLES/DNCM)    3.30E+05  1.50E+08  2.87E+07  1.51E+08  4.71E+08  3.43E+09  1.96E+10  4.73E+10  1.46E+11


NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
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```
1COLO-40 1-20-76 0945 PORTS 4,5,6
IMPACTOR FLOWRATE = 0.381 ACFM                     IMPACTOR TEMPERATURE =  280.0 F = 137.8 C                 SAMPLING DURATION = 120.00 MIN
IMPACTOR PRESSURE DROP = 0.2 IN. OF HG             STACK TEMPERATURE =  280.0 F = 137.8 C
ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.          STACK PRESSURE = 30.00 IN. OF HG     MAX. PARTICLE DIAMETER =  50.0 MICROMETERS
GAS COMPOSITION (PERCENT)          CO2 = 12.88          CO =  0.00          N2 = 73.60          O2 =  5.52          H2O =  8.00
CALC. MASS LOADING = 5.5796E-03 GR/ACF          8.4511E-03 GR/DNCF          1.2768E+01 MG/ACM          1.9339E+01 MG/DNCM
IMPACTOR STAGE                               S1        S2        S3        S4        S5        S6        S7        S8      FILTER
STAGE INDEX NUMBER                            1         2         3         4         5         6         7         8         9
D50 (MICROMETERS)                          8.48      8.08      4.95      3.31      1.80      0.87      0.54      0.26
MASS (MILLIGRAMS)                          3.08      2.16      2.18      2.48      2.33      2.71      1.52      0.07      0.00
MG/DNCM/STAGE                          3.60E+00  2.53E+00  2.55E+00  2.90E+00  2.73E+00  3.17E+00  1.78E+00  8.19E-02  0.00E-01
CUM. PERCENT OF MASS SMALLER THAN D50     81.37     68.30     55.11     40.11     26.01      9.62      0.42      0.00
CUM. (MG/ACM) SMALLER THAN D50         1.04E+01  8.72E+00  7.04E+00  5.12E+00  3.32E+00  1.23E+00  5.41E-02  0.00E-01
CUM. (MG/DNCM) SMALLER THAN D50        1.57E+01  1.32E+01  1.07E+01  7.76E+00  5.03E+00  1.86E+00  8.19E-02  0.00E-01
CUM. (GR/ACF) SMALLER THAN D50         4.54E-03  3.81E-03  3.08E-03  2.24E-03  1.45E-03  5.37E-04  2.36E-05  0.00E-01
CUM. (GR/DNCF) SMALLER THAN D50        6.88E-03  5.77E-03  4.66E-03  3.39E-03  2.20E-03  8.13E-04  3.58E-05  0.00E-01
GEO. MEAN DIA. (MICROMETERS)           2.06E+01  8.28E+00  6.33E+00  4.05E+00  2.47E+00  1.26E+00  6.86E-01  3.76E-01  1.84E-01
DM/DLOGD (MG/DNCM)                     4.68E+00  1.21E+02  1.20E+01  1.66E+01  1.06E+01  9.72E+00  8.78E+00  2.55E-01  0.00E-01
DN/DLOGD (NO. PARTICLES/DNCM)          4.26E+05  1.69E+08  3.77E+07  1.99E+08  5.65E+08  3.86E+09  2.17E+10  3.84E+09  0.00E-01

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
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CARD COLUMN NUMBERS

```
                  DATA DECK FOR PROGRAM  SPLIN1

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CARD COLUMN
NUMBERS

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                     DATA DECK FOR PROGRAM  GRAPH

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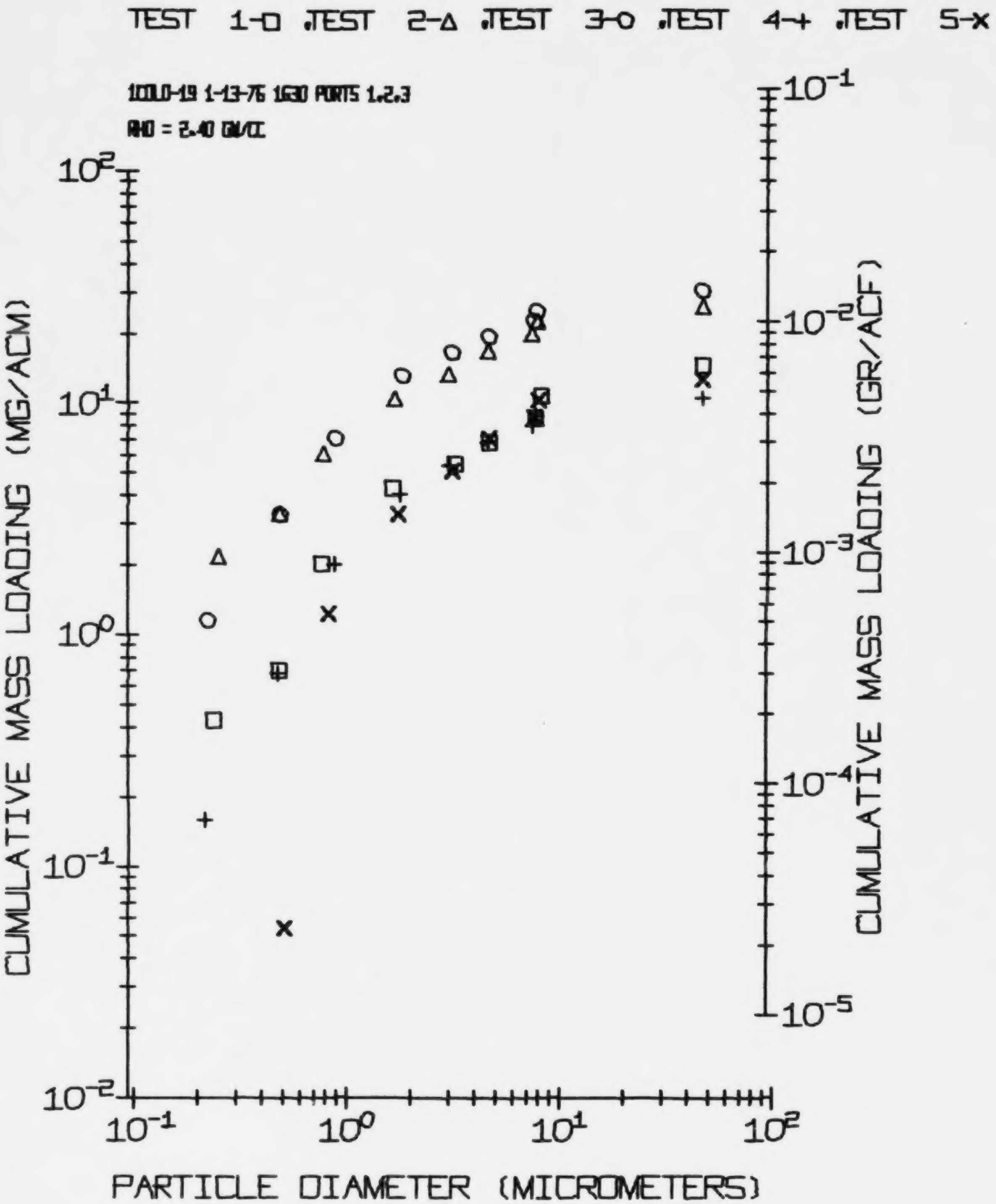

TEST 1-□ ,TEST 2-Δ ,TEST 3-O ,TEST 4-+ ,TEST 5-x
101LO-19 1-13-76 1630 PORTS 1,2,3
RHO = 2.40 GM/CC
CUMULATIVE MASS LOADING (MG/ACM)
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
CUMULATIVE MASS LOADING (GR/ACF)
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-1}
10^{0}
10^{1}
10^{2}
PARTICLE DIAMETER (MICROMETERS)

```
COLO-37 1-19-76 1544 PORTS 4,5,6
RHO= 2.40

                                                CUMULATIVE
   INTERVAL              DIAMETER         PERCENT CONCENTRATION
                         (MICRONS)

      5                  2.50E-01              4.04E+00
      6                  2.74E-01              4.60E+00
      7                  2.96E-01              5.11E+00
      8                  3.25E-01              5.80E+00
      9                  3.50E-01              6.44E+00
     10                  3.78E-01              7.14E+00
     11                  4.15E-01              8.09E+00
     12                  4.48E-01              8.96E+00
     13                  4.84E-01              9.93E+00
     14                  5.30E-01              1.12E+01
     15                  5.73E-01              1.24E+01
     16                  6.18E-01              1.37E+01
     17                  6.78E-01              1.54E+01
     18                  7.32E-01              1.70E+01
     19                  8.03E-01              1.89E+01
     20                  8.67E-01              2.07E+01
     21                  9.36E-01              2.26E+01
     22                  1.03E+00              2.50E+01
     23                  1.11E+00              2.70E+01
     24                  1.20E+00              2.91E+01
     25                  1.31E+00              3.17E+01
     26                  1.42E+00              3.39E+01
     27                  1.53E+00              3.61E+01
     28                  1.68E+00              3.87E+01
     29                  1.81E+00              4.07E+01
     30                  1.96E+00              4.27E+01
```

```
31          2.14E+00          4.49E+01
32          2.32E+00          4.67E+01
33          2.50E+00          4.85E+01
34          2.74E+00          5.05E+01
35          2.96E+00          5.20E+01
36          3.25E+00          5.39E+01
37          3.50E+00          5.54E+01
38          3.78E+00          5.70E+01
39          4.15E+00          5.90E+01
40          4.48E+00          6.08E+01
41          4.84E+00          6.28E+01
42          5.30E+00          6.55E+01
43          5.73E+00          6.80E+01
44          6.18E+00          7.05E+01
45          6.78E+00          7.37E+01
46          7.32E+00          7.63E+01
47          8.03E+00          7.95E+01
48          8.67E+00          8.21E+01
49          9.36E+00          8.44E+01
50          1.03E+01          8.69E+01
51          1.11E+01          8.86E+01
52          1.20E+01          9.01E+01
53          1.31E+01          9.17E+01
54          1.42E+01          9.28E+01
55          1.53E+01          9.37E+01
56          1.68E+01          9.46E+01
57          1.81E+01          9.53E+01
58          1.96E+01          9.59E+01
59          2.14E+01          9.65E+01
60          2.32E+01          9.70E+01
```

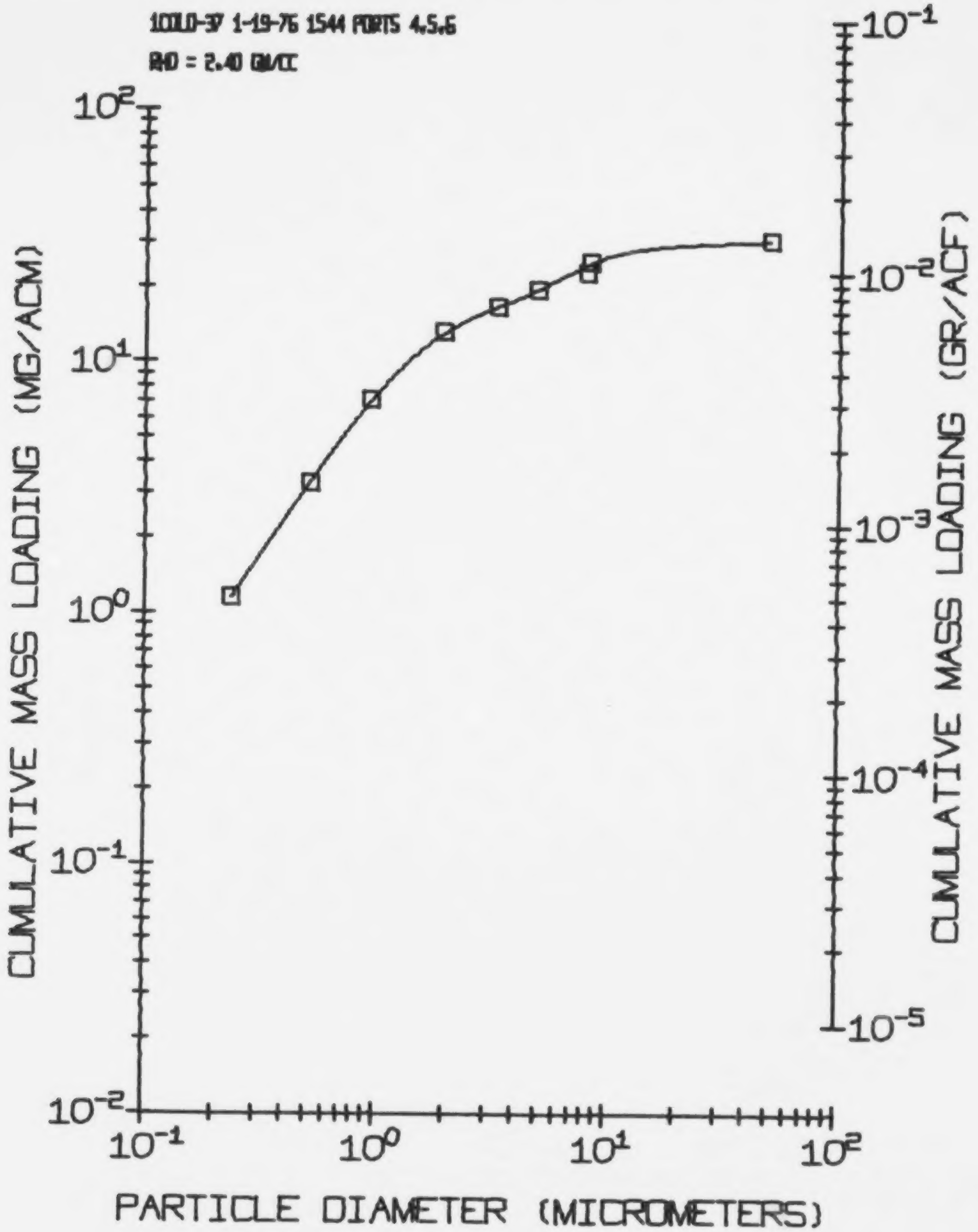
```
61              2,54E+01          9,75E+01
62              2,74E+01          9,78E+01
63              2,96E+01          9,82E+01
64              3,25E+01          9,86E+01
65              3,50E+01          9,89E+01
66              3,78E+01          9,92E+01
67              4,15E+01          9,95E+01
68              4,48E+01          9,98E+01
69              4,84E+01          1,00E+02
```

```
COLO-37 1-19-76 1544 PORTS 4,5,6
RHO= 2,40 GM/CC

                                                  CHANGE IN
     INTERVAL              DIAMETER           MASS CONCENTRATION
                           (MICRONS)             (MG/DNM3)

         1                 2,50E-01              6,10E+00
         2                 2,95E-01              7,53E+00
         3                 3,47E-01              9,26E+00
         4                 4,09E-01              1,15E+01
         5                 4,83E-01              1,42E+01
         6                 5,69E-01              1,73E+01
         7                 6,71E-01              2,05E+01
         8                 7,91E-01              2,38E+01
         9                 9,32E-01              2,68E+01
        10                 1,10E+00              2,92E+01
        11                 1,29E+00              3,06E+01
        12                 1,53E+00              3,03E+01
        13                 1,80E+00              2,84E+01
        14                 2,12E+00              2,58E+01
        15                 2,50E+00              2,38E+01
        16                 2,95E+00              2,20E+01
        17                 3,47E+00              2,15E+01
        18                 4,09E+00              2,37E+01
        19                 4,83E+00              3,00E+01
        20                 5,69E+00              3,48E+01
        21                 6,71E+00              3,70E+01
        22                 7,91E+00              3,69E+01
        23                 9,32E+00              3,12E+01
        24                 1,10E+01              2,31E+01
        25                 1,29E+01              1,65E+01
        26                 1,53E+01              1,72E+01
```

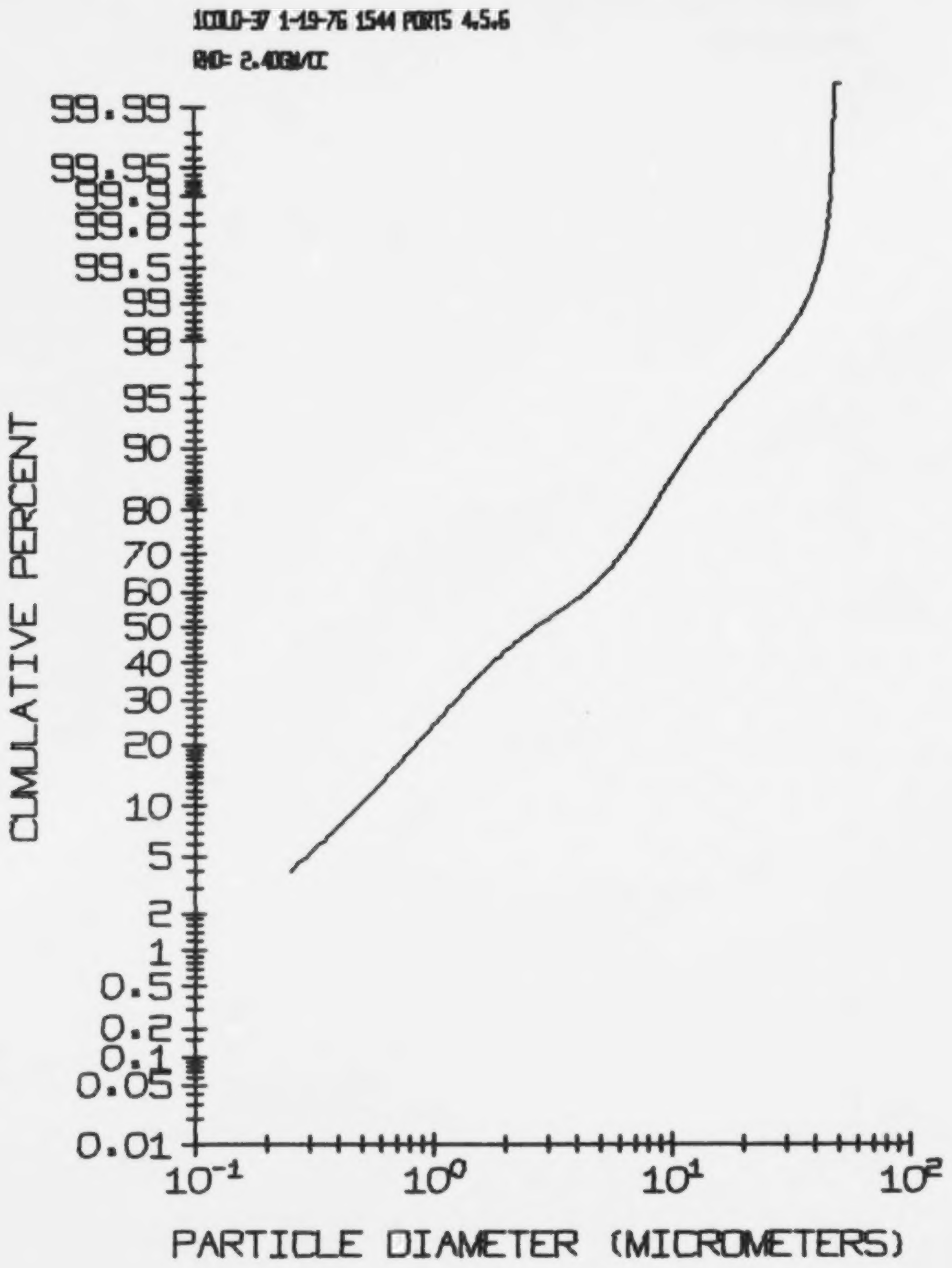
```
27            1.80E+01         8.99E+00
28            2.12E+01         6.79E+00
29            2.50E+01         5.51E+00
30            2.95E+01         4.78E+00
31            3.47E+01         4.28E+00
32            4.09E+01         3.93E+00
33            4.83E+01         3.64E+00
34            5.69E+01         3.35E+00
```

```
COLO-37 1-19-76 1544 PORTS 4,5,6
RHO= 2.40 GM/CC

                                            CHANGE IN
       INTERVAL            DIAMETER    NUMBER CONCENTRATION
                          (MICRONS)         (NO/DNM3)

           1              2.50E-01          3.11E+11
           2              2.95E-01          2.34E+11
           3              3.47E-01          1.76E+11
           4              4.09E-01          1.33E+11
           5              4.83E-01          1.01E+11
           6              5.69E-01          7.47E+10
           7              6.71E-01          5.42E+10
           8              7.91E-01          3.83E+10
           9              9.32E-01          2.63E+10
          10              1.10E+00          1.75E+10
          11              1.29E+00          1.12E+10
          12              1.53E+00          6.78E+09
          13              1.80E+00          3.87E+09
          14              2.12E+00          2.15E+09
          15              2.50E+00          1.21E+09
          16              2.95E+00          6.84E+08
          17              3.47E+00          4.09E+08
          18              4.09E+00          2.75E+08
          19              4.83E+00          2.12E+08
          20              5.69E+00          1.51E+08
          21              6.71E+00          9.77E+07
          22              7.91E+00          5.95E+07
          23              9.32E+00          3.07E+07
          24              1.10E+01          1.39E+07
          25              1.29E+01          6.06E+06
          26              1.53E+01          2.73E+06
```

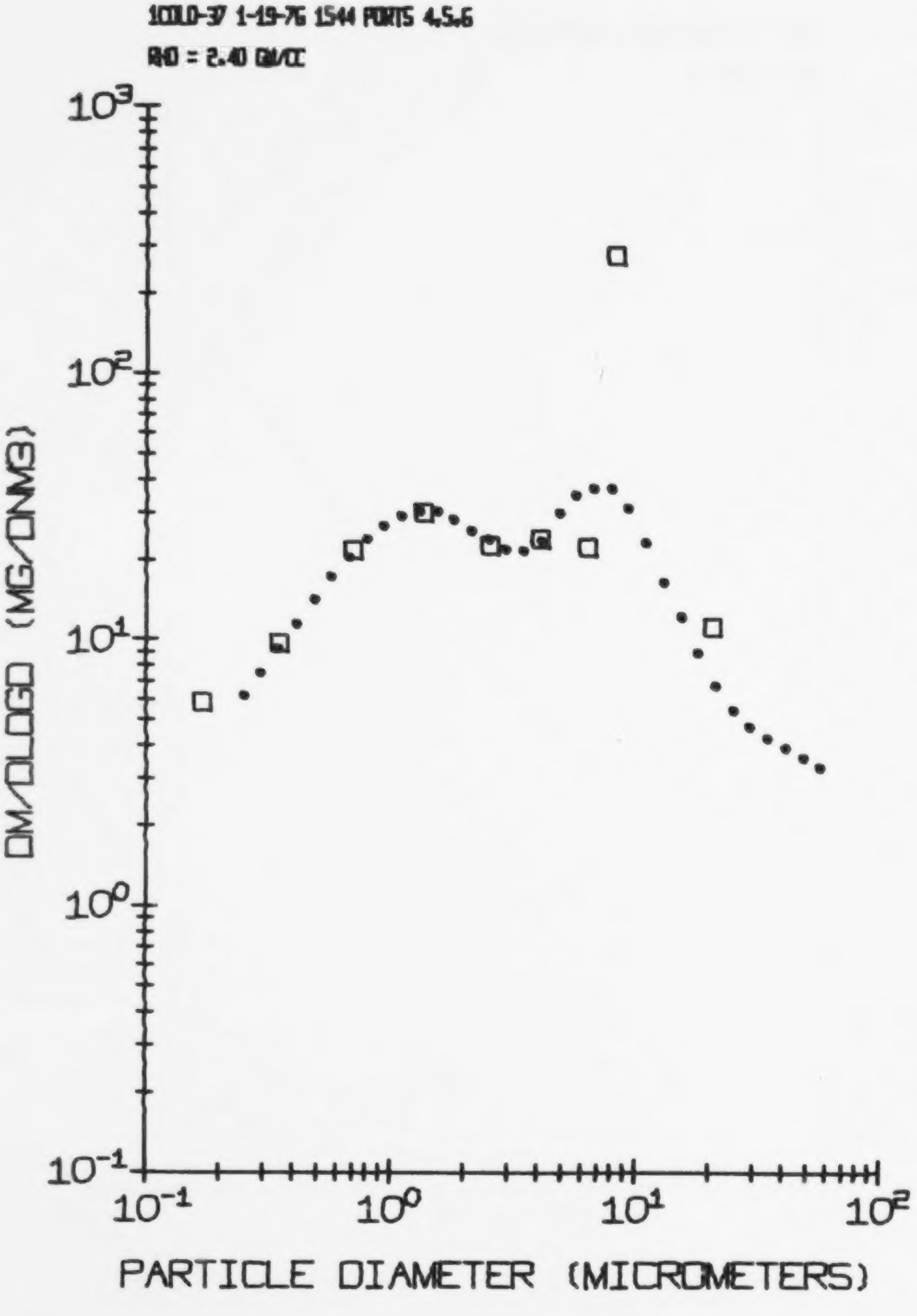
```
27          1.80E+01      1.23E+06
28          2.12E+01      5.66E+05
29          2.50E+01      2.81E+05
30          2.95E+01      1.49E+05
31          3.47E+01      8.13E+04
32          4.09E+01      4.55E+04
33          4.83E+01      2.58E+04
34          5.69E+01      1.45E+04
```

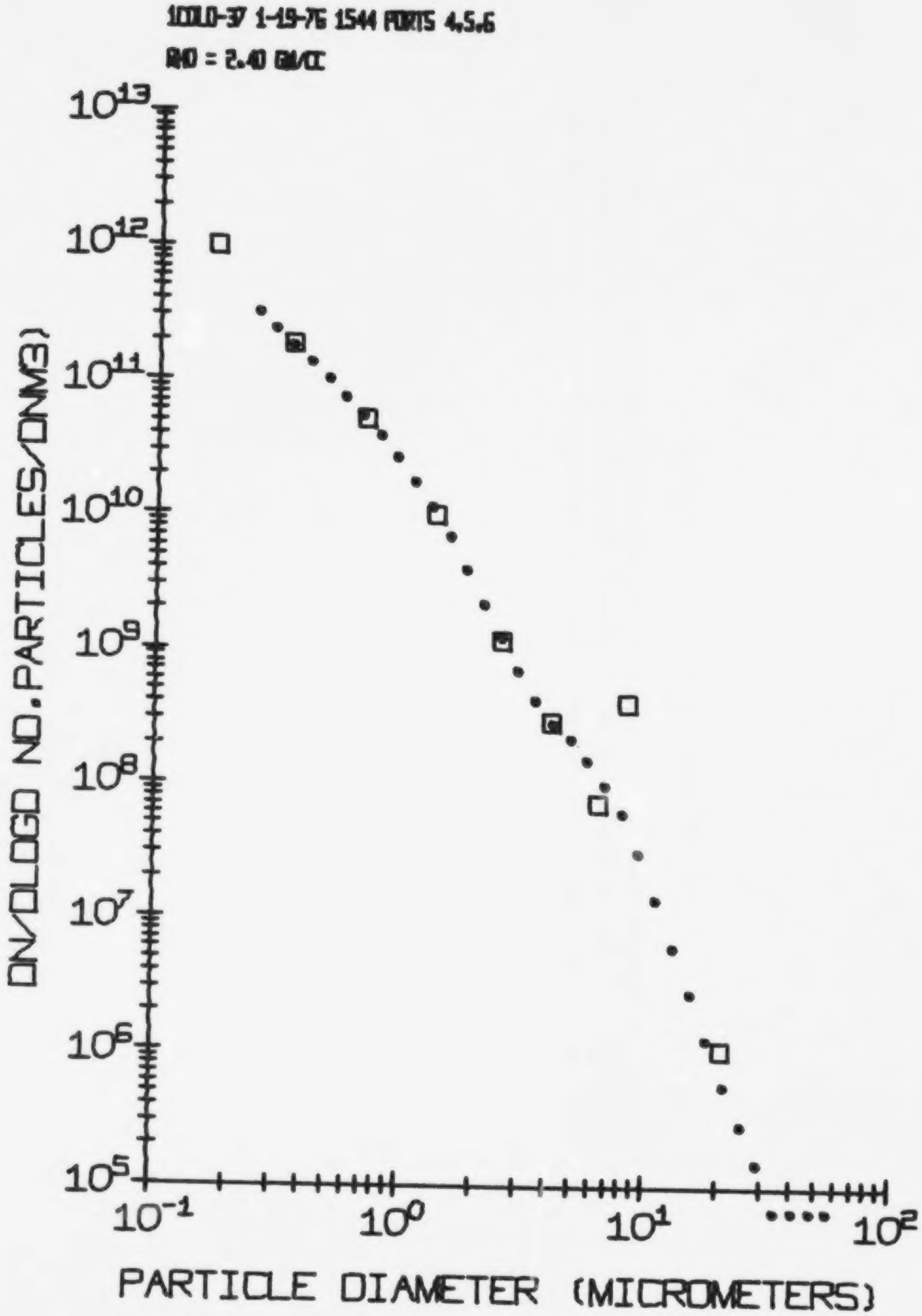


100LO-37 1-19-76 1544 PORTS 4.5.6
RHO = 2.40 GM/CC
10^2
10^1
10^0
10^-1
10^-2
CUMULATIVE MASS LOADING (MG/ACM)
10^-1
10^-2
10^-3
10^-4
10^-5
CUMULATIVE MASS LOADING (GR/ACF)
10^-1
10^0
10^1
10^2
PARTICLE DIAMETER (MICROMETERS)



1COLO-37 1-19-76 1544 PORTS 4,5,6
RHO= 2.40GM/CC
CUMULATIVE PERCENT
99.99
99.95
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
10^{-1}
10^{0}
10^{1}
10^{2}
PARTICLE DIAMETER (MICROMETERS)


1COLO-37 1-19-76 1544 PORTS 4,5,6
RHO = 2.40 GM/CC
10^3
10^2
10^1
10^0
10^{-1}
DM/DLOGD (MG/DNM3)
10^{-1}
10^0
10^1
10^2
PARTICLE DIAMETER (MICROMETERS)


100LD-37 1-19-76 1544 PORTS 4,5,6
RHO = 2.40 GM/CC
10^{13}
10^{12}
10^{11}
10^{10}
10^{9}
10^{8}
10^{7}
10^{6}
10^{5}
DN/DLOGD NO.PARTICLES/DNM3)
10^{-1}
10^{0}
10^{1}
10^{2}
PARTICLE DIAMETER (MICROMETERS)

CARD COLUMN
NUMBERS

```
                       DATA DFCK FOR PROGRAM  STATIS

         11111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
--------------------------------------------------------------------------------
2
1000001111
0,000
21
```

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CIDRS VERSION 1 TEST FOR ANDERSEN.
RHO= 2.40 GM/CC

                          MEAN CUMULATIVE
INTERVAL   DIAMETER   MASS CONCENTRATION  UPPER CONFIDENCE   LOWER CONFIDENCE
           (MICRONS)       (MG/ACM)             LIMIT              LIMIT
                                               (MG/ACM)           (MG/ACM)

    1      2.50E-01       0.00E-01
    2      2.71E-01       3.46E-02            7.89E-03          -7.89E-03
    3      2.95E-01       9.35E-02            5.71E-02           1.22E-02
    4      3.20E-01       1.62E-01            1.26E-01           6.12E-02
    5      3.47E-01       2.41E-01            2.04E-01           1.20E-01
    6      3.77E-01       3.32E-01            2.91E-01           1.90E-01
    7      4.09E-01       4.40E-01            3.92E-01           2.72E-01
    8      4.45E-01       5.66E-01            5.10E-01           3.69E-01
    9      4.83E-01       7.16E-01            6.48E-01           4.85E-01
   10      5.24E-01       8.93E-01            8.09E-01           6.23E-01
   11      5.69E-01       1.10E+00            9.98E-01           7.88E-01
   12      6.18E-01       1.34E+00            1.22E+00           9.85E-01
   13      6.71E-01       1.62E+00            1.47E+00           1.22E+00
   14      7.28E-01       1.94E+00            1.76E+00           1.48E+00
   15      7.91E-01       2.29E+00            2.09E+00           1.79E+00
   16      8.58E-01       2.66E+00            2.44E+00           2.13E+00
   17      9.32E-01       3.06E+00            2.82E+00           2.49E+00
   18      1.01E+00       3.47E+00            3.23E+00           2.88E+00
   19      1.10E+00       3.88E+00            3.65E+00           3.28E+00
   20      1.19E+00       4.30E+00            4.08E+00           3.69E+00
   21      1.29E+00       4.72E+00            4.51E+00           4.10E+00
   22      1.41E+00       5.12E+00            4.93E+00           4.51E+00
   23      1.53E+00       5.50E+00            5.34E+00           4.90E+00
   24      1.66E+00       5.86E+00            5.74E+00           5.26E+00
   25      1.80E+00       6.20E+00            6.10E+00           5.61E+00
   26      1.95E+00       6.51E+00            6.45E+00           5.94E+00
   27      2.12E+00       6.82E+00            6.78E+00           6.25E+00
   28      2.30E+00       7.11E+00            7.09E+00           6.54E+00
   29      2.50E+00       7.41E+00            7.39E+00           6.83E+00
   30      2.71E+00       7.72E+00            7.70E+00           7.13E+00
   31      2.95E+00       8.03E+00            8.01E+00           7.42E+00
   32      3.20E+00       8.36E+00            8.33E+00           7.73E+00
   33      3.47E+00       8.71E+00            8.66E+00           8.06E+00
   34      3.77E+00       9.09E+00            9.02E+00           8.40E+00
   35      4.09E+00       9.50E+00            9.40E+00           8.77E+00
   36      4.45E+00       9.95E+00            9.82E+00           9.18E+00
   37      4.83E+00       1.05E+01            1.03E+01           9.62E+00
   38      5.24E+00       1.10E+01            1.08E+01           1.01E+01
   39      5.69E+00       1.16E+01            1.13E+01           1.07E+01
   40      6.18E+00       1.22E+01            1.19E+01           1.12E+01
   41      6.71E+00       1.28E+01            1.26E+01           1.18E+01
   42      7.28E+00       1.35E+01            1.32E+01           1.25E+01
   43      7.91E+00       1.41E+01            1.38E+01           1.31E+01
                                              1.45E+01           1.37E+01
```

```
CIDRS VERSION 1 TEST FOR ANDERSEN.
RHO= 2.40 GM/CC
INTERVAL   DIAMETER      RECORDS EXCLUDED FROM MEAN
                       CUMULATIVE MASS CONCENTRATION

    1      2.50E-01          5
    2      2.71E-01        NONE
    3      2.95E-01        NONE
    4      3.20E-01        NONE
    5      3.47E-01        NONE
    6      3.77E-01        NONE
    7      4.09E-01        NONE
    8      4.45E-01        NONE
    9      4.83E-01        NONE
   10      5.24E-01        NONE
   11      5.69E-01        NONE
   12      6.18E-01        NONE
   13      6.71E-01        NONE
   14      7.28E-01        NONE
   15      7.91E-01        NONE
   16      8.58E-01        NONE
   17      9.32E-01        NONE
   18      1.01E+00        NONE
   19      1.10E+00        NONE
   20      1.19E+00        NONE
   21      1.29E+00        NONE
   22      1.41E+00        NONE
   23      1.53E+00        NONE
   24      1.66E+00        NONE
   25      1.80E+00        NONE
   26      1.95E+00        NONE
   27      2.12E+00        NONE
   28      2.30E+00        NONE
   29      2.50E+00        NONE
   30      2.71E+00        NONE
   31      2.95E+00        NONE
   32      3.20E+00        NONE
   33      3.47E+00        NONE
   34      3.77E+00        NONE
   35      4.09E+00        NONE
   36      4.45E+00        NONE
   37      4.83E+00        NONE
   38      5.24E+00        NONE
   39      5.69E+00        NONE
   40      6.18E+00        NONE
   41      6.71E+00        NONE
   42      7.28E+00        NONE
   43      7.91E+00        NONE
```

```
CIDRS VERSION 1 TEST FOR ANDERSEN.
RHO= 2.40 GM/CC

                              MEAN CUMULATIVE     UPPER CONFIDENCE    LOWER CONFIDENCE
INTERVAL     DIAMETER      MASS CONCENTRATION          LIMIT               LIMIT
             (MICRONS)         (PERCENT)             (PERCENT)           (PERCENT)
    1        2.50E-01          0.00E-01              4.14E-02           -4.14E-02
    2        2.71E-01          1.82E-01              2.99E-01            6.38E-02
    3        2.95E-01          4.90E-01              6.60E-01            3.21E-01
    4        3.20E-01          8.49E-01              1.07E+00            6.31E-01
    5        3.47E-01          1.26E+00              1.53E+00            9.97E-01
    6        3.77E-01          1.74E+00              2.06E+00            1.43E+00
    7        4.09E-01          2.30E+00              2.67E+00            1.94E+00
    8        4.45E-01          2.97E+00              3.39E+00            2.54E+00
    9        4.83E-01          3.75E+00              4.24E+00            3.27E+00
   10        5.24E-01          4.68E+00              5.23E+00            4.13E+00
   11        5.69E-01          5.78E+00              6.39E+00            5.16E+00
   12        6.18E-01          7.05E+00              7.72E+00            6.37E+00
   13        6.71E-01          8.51E+00              9.24E+00            7.79E+00
   14        7.28E-01          1.02E+01              1.09E+01            9.39E+00
   15        7.91E-01          1.20E+01              1.28E+01            1.12E+01
   16        8.58E-01          1.39E+01              1.48E+01            1.31E+01
   17        9.32E-01          1.60E+01              1.69E+01            1.51E+01
   18        1.01E+00          1.82E+01              1.91E+01            1.72E+01
   19        1.10E+00          2.04E+01              2.14E+01            1.94E+01
   20        1.19E+00          2.26E+01              2.36E+01            2.15E+01
   21        1.29E+00          2.47E+01              2.59E+01            2.36E+01
   22        1.41E+00          2.68E+01              2.80E+01            2.57E+01
   23        1.53E+00          2.88E+01              3.01E+01            2.76E+01
   24        1.66E+00          3.07E+01              3.20E+01            2.94E+01
   25        1.80E+00          3.25E+01              3.38E+01            3.11E+01
   26        1.95E+00          3.41E+01              3.55E+01            3.28E+01
   27        2.12E+00          3.57E+01              3.72E+01            3.43E+01
   28        2.30E+00          3.73E+01              3.88E+01            3.58E+01
   29        2.50E+00          3.89E+01              4.04E+01            3.74E+01
   30        2.71E+00          4.05E+01              4.20E+01            3.89E+01
   31        2.95E+00          4.21E+01              4.37E+01            4.05E+01
   32        3.20E+00          4.38E+01              4.54E+01            4.22E+01
   33        3.47E+00          4.57E+01              4.73E+01            4.41E+01
   34        3.77E+00          4.76E+01              4.93E+01            4.60E+01
   35        4.09E+00          4.98E+01              5.15E+01            4.81E+01
   36        4.45E+00          5.22E+01              5.39E+01            5.05E+01
   37        4.83E+00          5.48E+01              5.66E+01            5.31E+01
   38        5.24E+00          5.77E+01              5.95E+01            5.59E+01
   39        5.69E+00          6.07E+01              6.26E+01            5.89E+01
   40        6.18E+00          6.40E+01              6.58E+01            6.21E+01
   41        6.71E+00          6.73E+01              6.92E+01            6.53E+01
   42        7.28E+00          7.06E+01              7.26E+01            6.87E+01
   43        7.91E+00          7.40E+01              7.60E+01            7.20E+01
```

```
CIDRS VERSION 1 TEST FOR ANDERSEN.
RHO= 2.40 GM/CC
                           MEAN CHANGE            STANDARD   UPPER CONFIDENCE   LOWER CONFIDENCE
INTERVAL   DIAMETER   IN MASS CONCENTRATION      DEVIATION        LIMIT              LIMIT
                             (MG/DNM3)           (MG/DNM3)      (MG/DNM3)          (MG/DNM3)
    1      2.50E-01          9.58E-01            9.02E-01       1.31E+00           6.09E-01
    2      2.95E-01          2.74E+00            2.99E+00       3.74E+00           1.75E+00
    3      3.47E-01          3.65E+00            3.73E+00       4.89E+00           2.40E+00
    4      4.09E-01          5.04E+00            4.69E+00       6.61E+00           3.47E+00
    5      4.83E-01          7.05E+00            5.83E+00       8.99E+00           5.10E+00
    6      5.69E-01          9.76E+00            6.81E+00       1.20E+01           7.49E+00
    7      6.71E-01          1.29E+01            6.89E+00       1.52E+01           1.06E+01
    8      7.91E-01          1.56E+01            6.71E+00       1.78E+01           1.34E+01
    9      9.32E-01          1.75E+01            7.11E+00       1.98E+01           1.51E+01
   10      1.10E+00          1.81E+01            7.75E+00       2.07E+01           1.55E+01
   11      1.29E+00          1.76E+01            8.54E+00       2.05E+01           1.48E+01
   12      1.53E+00          1.59E+01            9.20E+00       1.90E+01           1.28E+01
   13      1.80E+00          1.40E+01            9.17E+00       1.71E+01           1.10E+01
   14      2.12E+00          1.29E+01            8.51E+00       1.57E+01           1.00E+01
   15      2.50E+00          1.29E+01            7.74E+00       1.55E+01           1.03E+01
   16      2.95E+00          1.38E+01            7.27E+00       1.63E+01           1.14E+01
   17      3.47E+00          1.56E+01            7.55E+00       1.82E+01           1.31E+01
   18      4.09E+00          1.85E+01            8.31E+00       2.12E+01           1.57E+01
   19      4.83E+00          2.28E+01            9.42E+00       2.60E+01           1.97E+01
   20      5.69E+00          2.60E+01            1.03E+01       2.95E+01           2.26E+01
   21      6.71E+00          2.76E+01            1.07E+01       3.11E+01           2.40E+01
   22      7.91E+00          2.76E+01            1.04E+01       3.11E+01           2.41E+01
```

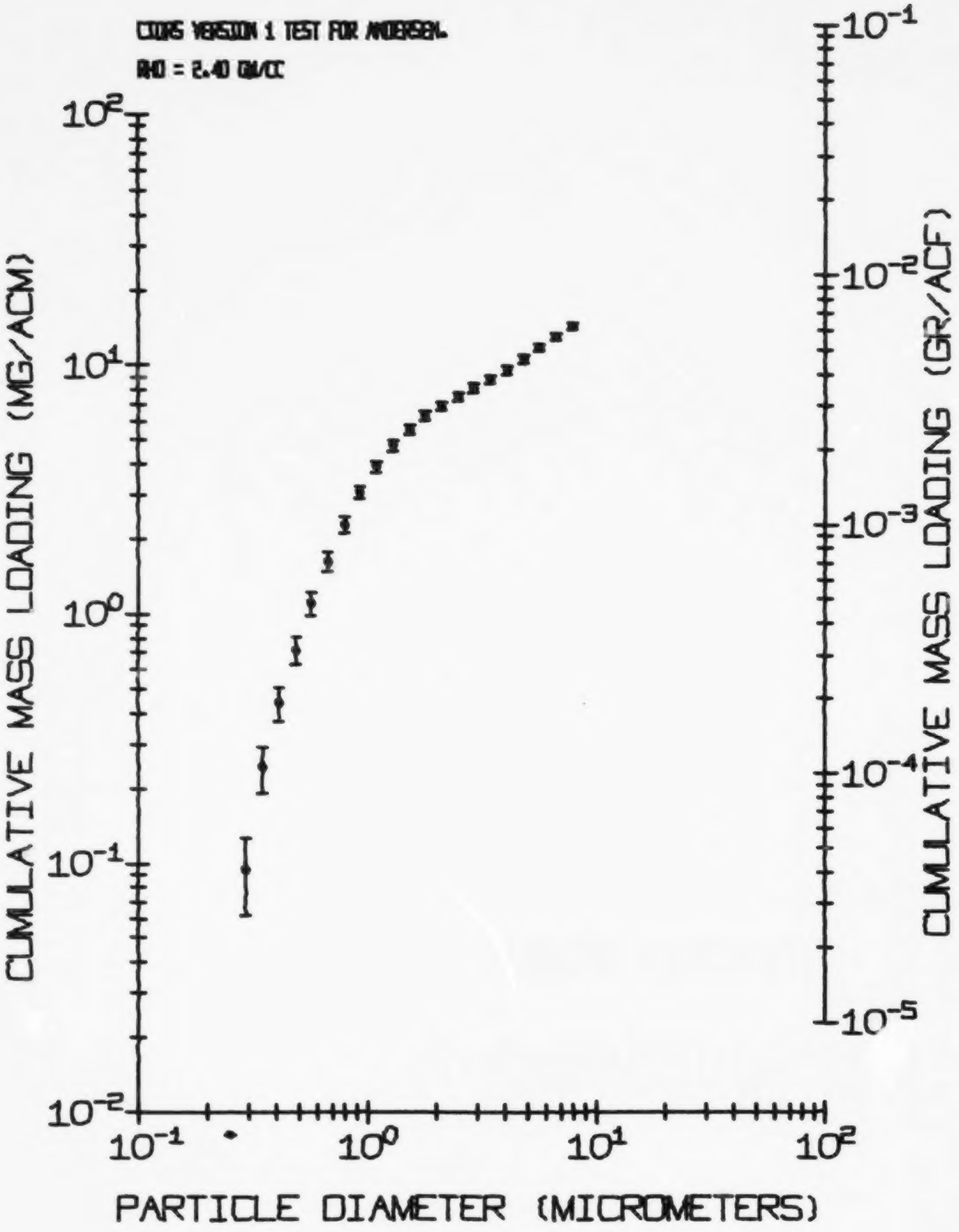
```
CIDRS VERSION 1 TEST FOR ANDERSEN.
RHO= 2.40 GM/CC
INTERVAL   DIAMETER    RECORDS EXCLUDED FROM MEAN
                      CHANGE IN MASS CONTRATION

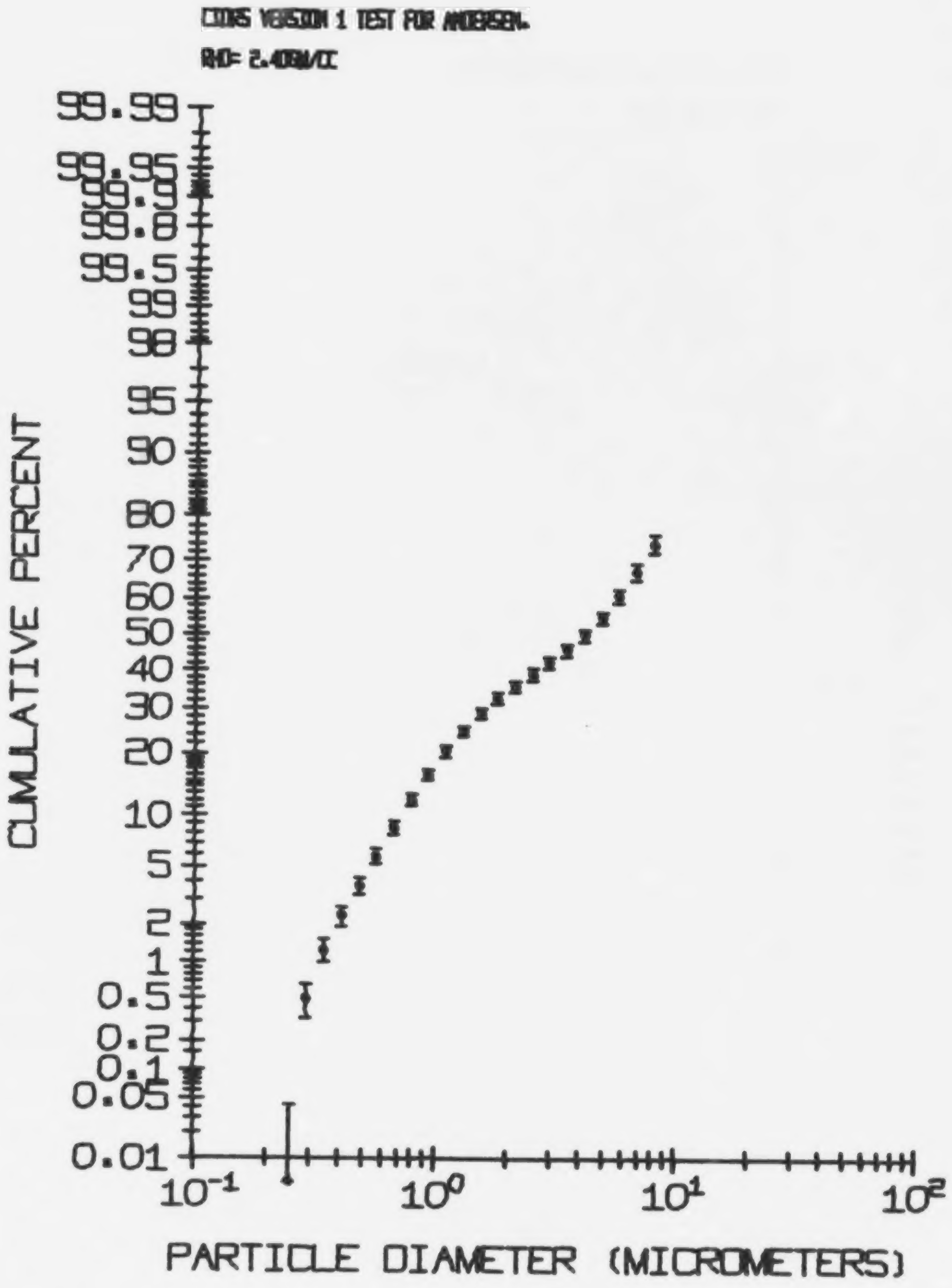
    1      2.50E-01        5
    2      2.95E-01      NONE
    3      3.47E-01      NONE
    4      4.09E-01      NONE
    5      4.83E-01      NONE
    6      5.69E-01      NONE
    7      6.71E-01      NONE
    8      7.91E-01      NONE
    9      9.32E-01      NONE
   10      1.10E+00      NONE
   11      1.29E+00      NONE
   12      1.53E+00      NONE
   13      1.80E+00      NONE
   14      2.12E+00      NONE
   15      2.50E+00      NONE
   16      2.95E+00      NONE
   17      3.47E+00      NONE
   18      4.09E+00      NONE
   19      4.83E+00      NONE
   20      5.69E+00      NONE
   21      6.71E+00      NONE
   22      7.91E+00      NONE
```

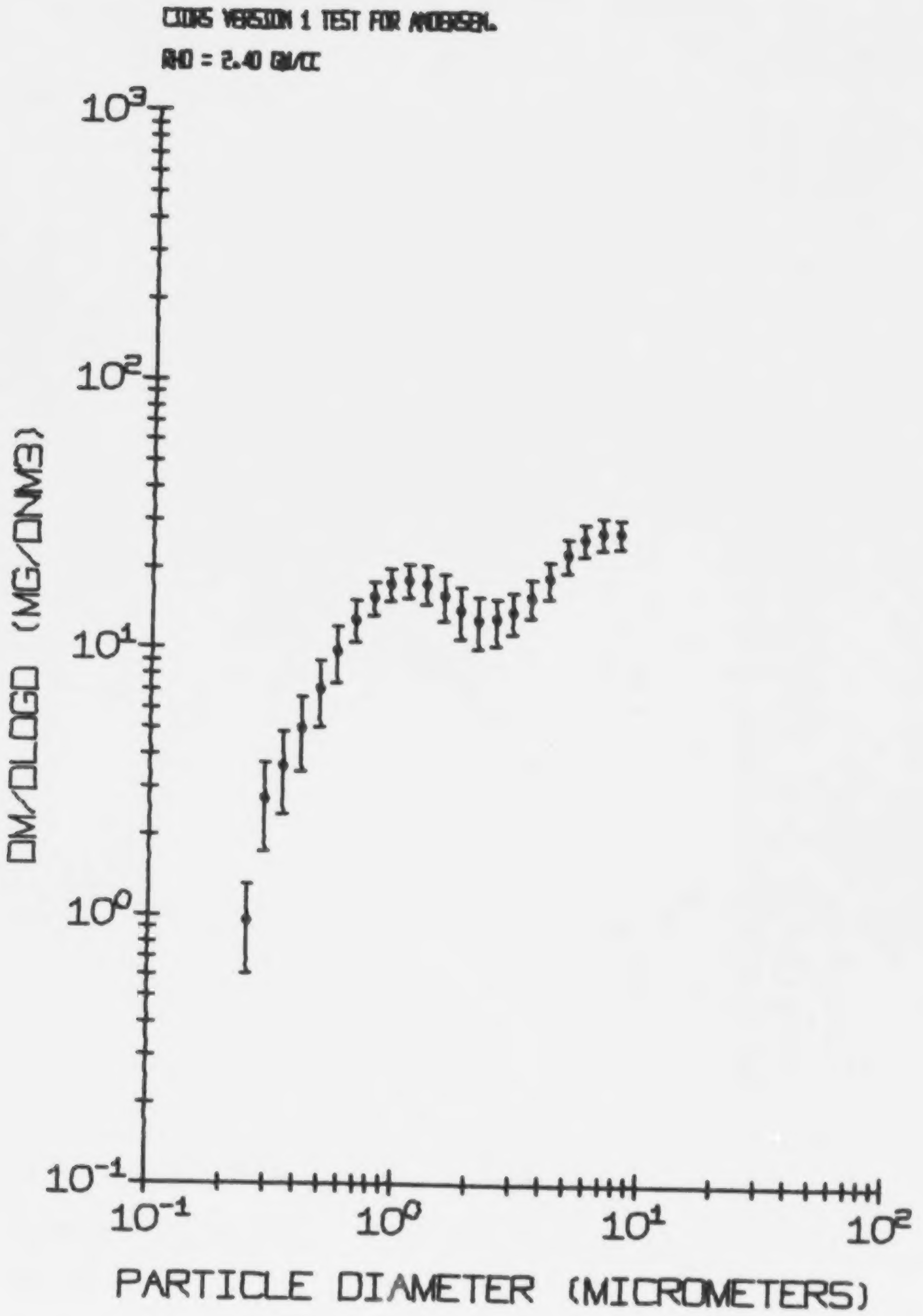
```
CIDRS VERSION 1 TEST FOR ANDERSEN.
RHO= 2.40 GM/CC
                              MEAN CHANGE             STANDARD   UPPER CONFIDENCE   LOWER CONFIDENCE
INTERVAL   DIAMETER   IN NUMBER CONCENTRATION    DEVIATION       LIMIT              LIMIT
                              (NO/DNM3)            (NO/DNM3)      (NO/DNM3)          (NO/DNM3)
    1      2.50E-01           4.88E+10             4.60E+10       6.65E+10           3.10E+10
    2      2.95E-01           8.53E+10             9.29E+10       1.16E+11           5.43E+10
    3      3.47E-01           6.92E+10             7.08E+10       9.28E+10           4.56E+10
    4      4.09E-01           5.84E+10             5.44E+10       7.66E+10           4.03E+10
    5      4.83E-01           4.99E+10             4.13E+10       6.37E+10           3.61E+10
    6      5.69E-01           4.22E+10             2.94E+10       5.20E+10           3.24E+10
    7      6.71E-01           3.40E+10             1.82E+10       4.01E+10           2.79E+10
    8      7.91E-01           2.51E+10             1.08E+10       2.87E+10           2.15E+10
    9      9.32E-01           1.72E+10             6.99E+09       1.95E+10           1.49E+10
   10      1.10E+00           1.09E+10             4.65E+09       1.24E+10           9.33E+09
   11      1.29E+00           6.45E+09             3.13E+09       7.50E+09           5.41E+09
   12      1.53E+00           3.56E+09             2.06E+09       4.25E+09           2.87E+09
   13      1.80E+00           1.92E+09             1.25E+09       2.33E+09           1.50E+09
   14      2.12E+00           1.07E+09             7.10E+08       1.31E+09           8.36E+08
   15      2.50E+00           6.58E+08             3.94E+08       7.89E+08           5.26E+08
   16      2.95E+00           4.30E+08             2.26E+08       5.05E+08           3.54E+08
   17      3.47E+00           2.97E+08             1.43E+08       3.45E+08           2.49E+08
   18      4.09E+00           2.14E+08             9.64E+07       2.46E+08           1.82E+08
   19      4.83E+00           1.61E+08             6.66E+07       1.84E+08           1.39E+08
   20      5.69E+00           1.12E+08             4.46E+07       1.27E+08           9.76E+07
   21      6.71E+00           7.28E+07             2.81E+07       8.21E+07           6.34E+07
   22      7.91E+00           4.44E+07             1.68E+07       5.00E+07           3.88E+07
```

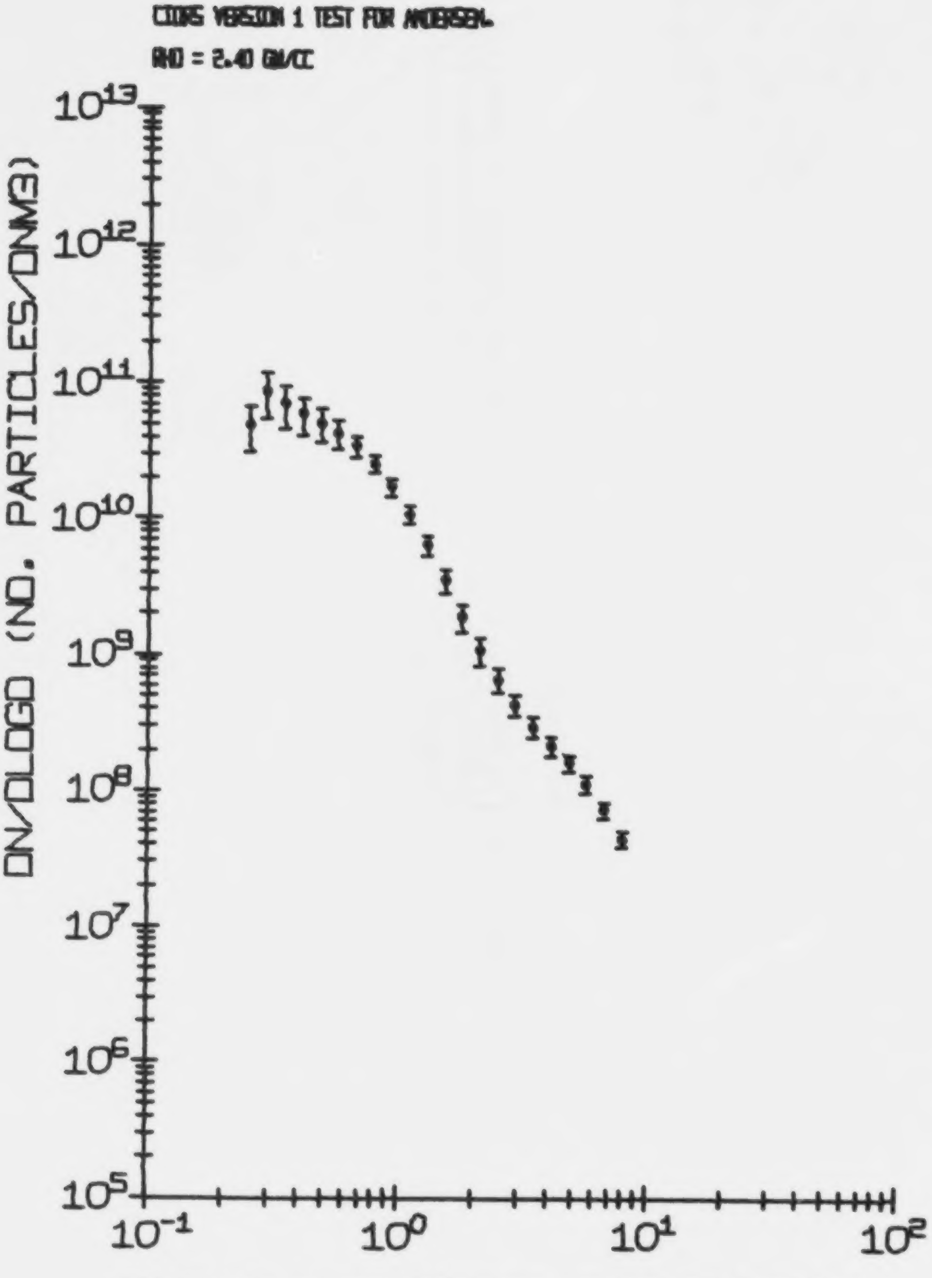
```
CIDRS VERSION 1 TEST FOR ANDERSEN.
RHO= 2.40 GM/CC
INTERVAL   DIAMETER    RECORDS EXCLUDED FROM MEAN
                      CHANGE IN NUMBER CONCENTRATION

    1      2.50E-01        5
    2      2.95E-01      NONE
    3      3.47E-01      NONE
    4      4.09E-01      NONE
    5      4.83E-01      NONE
    6      5.69E-01      NONE
    7      6.71E-01      NONE
    8      7.91E-01      NONE
    9      9.32E-01      NONE
   10      1.10E+00      NONE
   11      1.29E+00      NONE
   12      1.53E+00      NONE
   13      1.80E+00      NONE
   14      2.12E+00      NONE
   15      2.50E+00      NONE
   16      2.95E+00      NONE
   17      3.47E+00      NONE
   18      4.09E+00      NONE
   19      4.83E+00      NONE
   20      5.69E+00      NONE
   21      6.71E+00      NONE
   22      7.91E+00      NONE
```


CIDRS VERSION 1 TEST FOR ANDERSEN.
RHO = 2.40 GM/CC
CUMULATIVE MASS LOADING (MG/ACM)
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
CUMULATIVE MASS LOADING (GR/ACF)
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-1}
10^{0}
10^{1}
10^{2}
PARTICLE DIAMETER (MICROMETERS)


CIDRS VERSION 1 TEST FOR ANDERSEN.
RHO= 2.40GM/CC
CUMULATIVE PERCENT
99.99
99.95
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
10^{-1}
10^{0}
10^{1}
10^{2}
PARTICLE DIAMETER (MICROMETERS)


CIDRS VERSION 1 TEST FOR ANDERSEN.
RHO = 2.40 GM/CC
10^3
10^2
10^1
10^0
10^{-1}
DM/DLOGD (MG/DNM3)
10^{-1}
10^0
10^1
10^2
PARTICLE DIAMETER (MICROMETERS)


CIDRS VERSION 1 TEST FOR ANDERSEN.
RHO = 2.40 GM/CC
10^{13}
10^{12}
10^{11}
10^{10}
10^{9}
10^{8}
10^{7}
10^{6}
10^{5}
DN/DLOGD (NO. PARTICLES/DNM3)
10^{-1}
10^{0}
10^{1}
10^{2}
PARTICLE DIAMETER (MICROMETERS)

CARD COLUMN
NUMBERS

```
                  DATA DECK FOR PROGRAM  PENTRA
         111111111122222222223333333333444444444455555555556666666666777777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
--------------------------------------------------------------------------------
CIDRS VERSION 1 TEST FOR PENETRATION-EFFICIENCY.  PENTRA
00
```

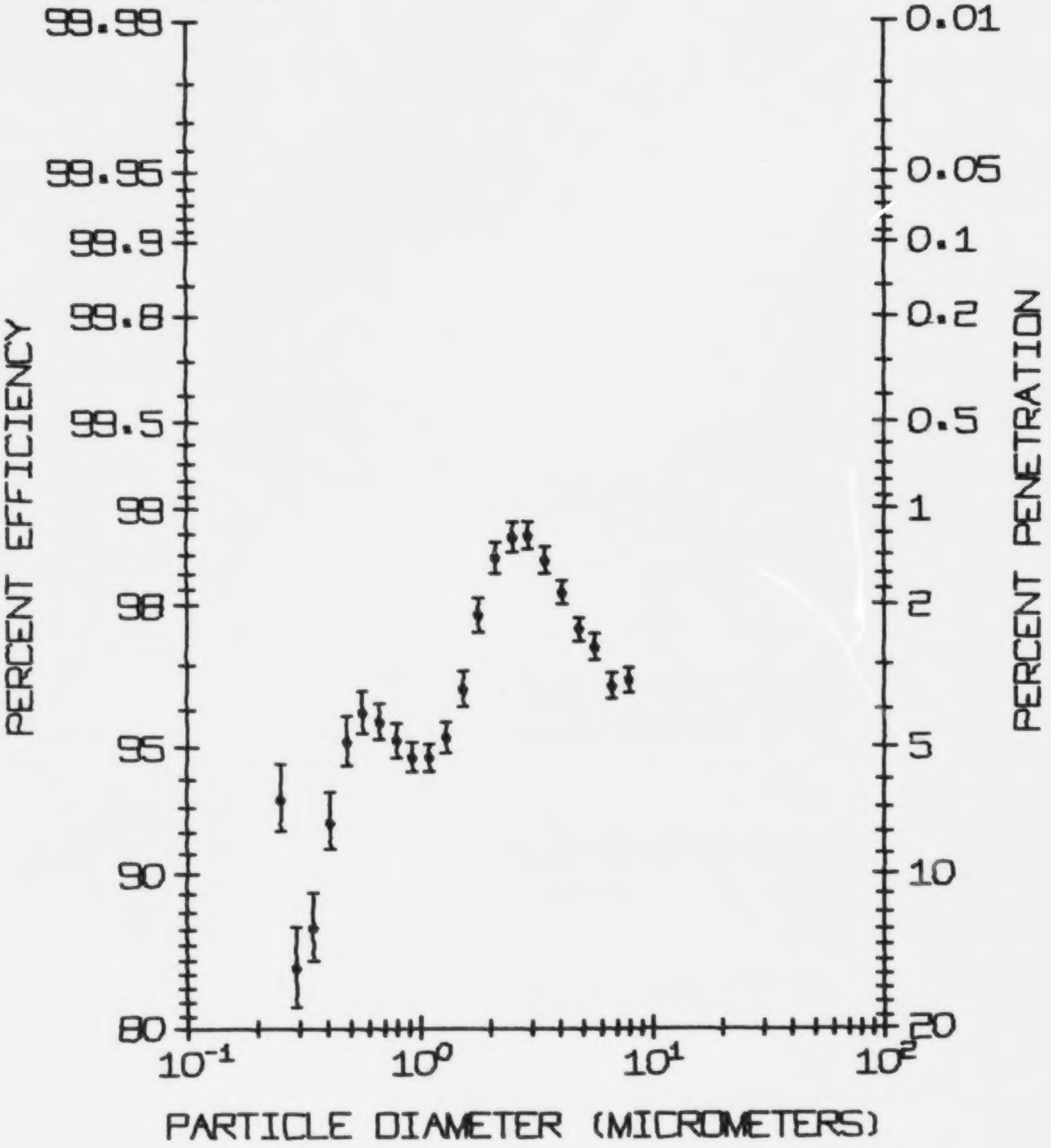
```
CIDRS VERSION 1 TEST FOR PENETRATION-EFFICIENCY.  PENTRA
RHO= 2.40 GM/CC
                                        UPPER CONFIDENCE   LOWER CONFIDENCE
                           AVERAGE          LIMIT OF           LIMIT OF
 INTERVAL    DIAMETER    EFFICIENCY        EFFICIENCY         EFFICIENCY

     1.       0.2500      93.2498           94.4870            92.0127
     2.       0.2947      84.4259           87.1595            81.6923
     3.       0.3474      87.0272           89.1122            84.9423
     4.       0.4095      92.3900           93.5582            91.2217
     5.       0.4827      95.1672           95.8692            94.4651
     6.       0.5690      95.9378           96.4654            95.4102
     7.       0.6707      95.7053           96.1838            95.2267
     8.       0.7906      95.1794           95.6560            94.7028
     9.       0.9319      94.7063           95.1633            94.2493
    10.       1.0985      94.6757           95.1040            94.2474
    11.       1.2949      95.2842           95.7126            94.8558
    12.       1.5264      96.4848           96.8712            96.0984
    13.       1.7992      97.8405           98.0882            97.5928
    14.       2.1209      98.5539           98.7183            98.3895
    15.       2.5000      98.7609           98.8906            98.6313
    16.       2.9469      98.7721           98.8930            98.6512
    17.       3.4737      98.5311           98.6656            98.3966
    18.       4.0947      98.1473           98.3042            97.9904
    19.       4.8267      97.6214           97.8088            97.4340
    20.       5.6896      97.3225           97.5439            97.1011
    21.       6.7067      96.5711           96.8522            96.2899
    22.       7.9057      96.6740           96.9464            96.4015
```

PENETRATION-EFFICIENCY

CIDRS VERSION 1 TEST FOR PENETRATION-EFFICIENCY. PENTRA

RHO= 2.40 GM/CC



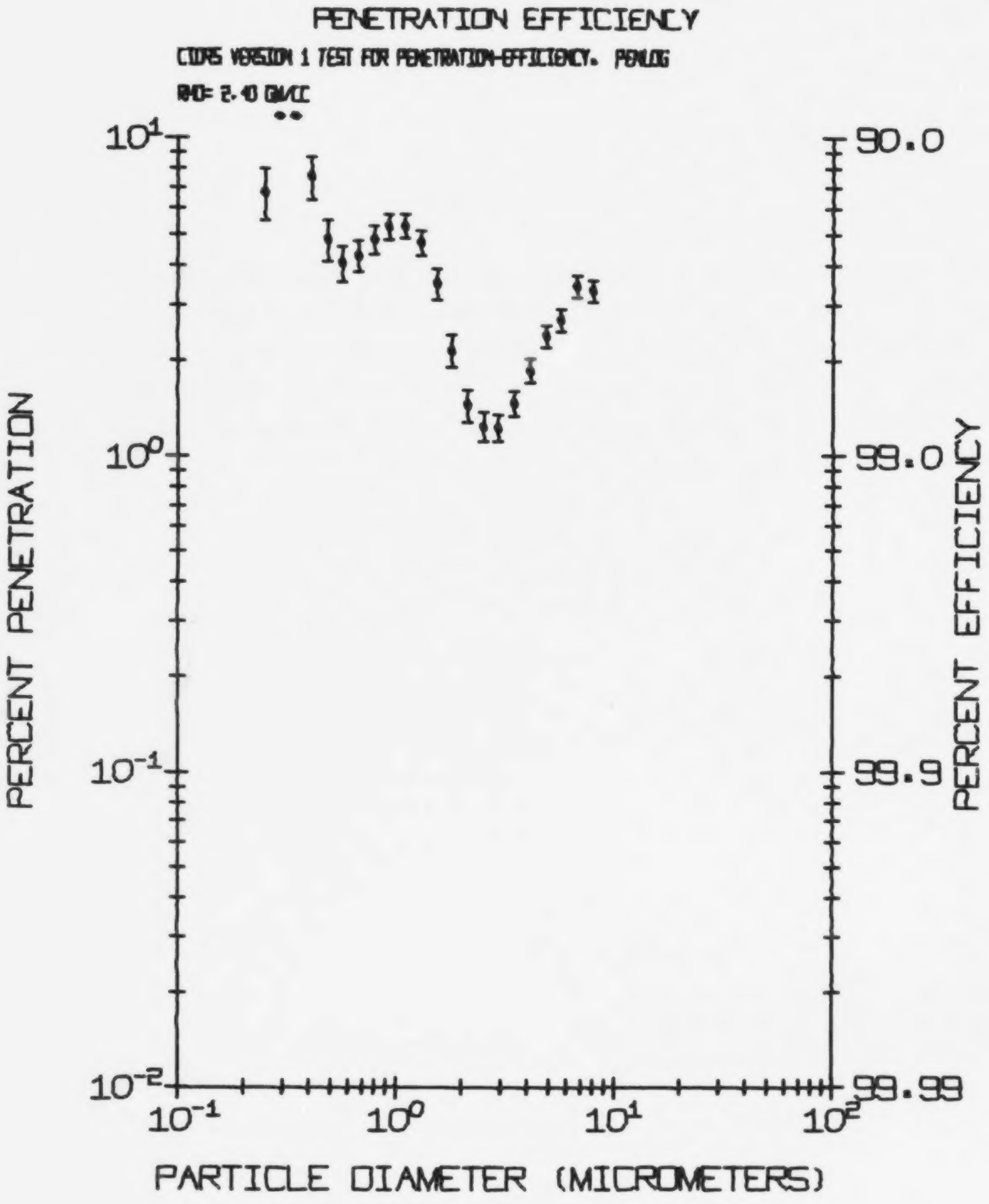
CARD COLUMN
NUMBERS

```
                        DATA DECK FOR PROGRAM  PENLOG

         11111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
--------------------------------------------------------------------------------
CIDRS VERSION 1 TEST FOR PENETRATION-EFFICIENCY.  PENLOG
0
STOP  000000
```

```
 CIDRS VERSION 1 TEST FOR PENETRATION-EFFICIENCY.  PENLOG
RHO= 2.40 GM/CC
                                      UPPER CONFIDENCE   LOWER CONFIDENCE
                          AVERAGE        LIMIT OF           LIMIT OF
 INTERVAL   DIAMETER    EFFICIENCY      EFFICIENCY         EFFICIENCY

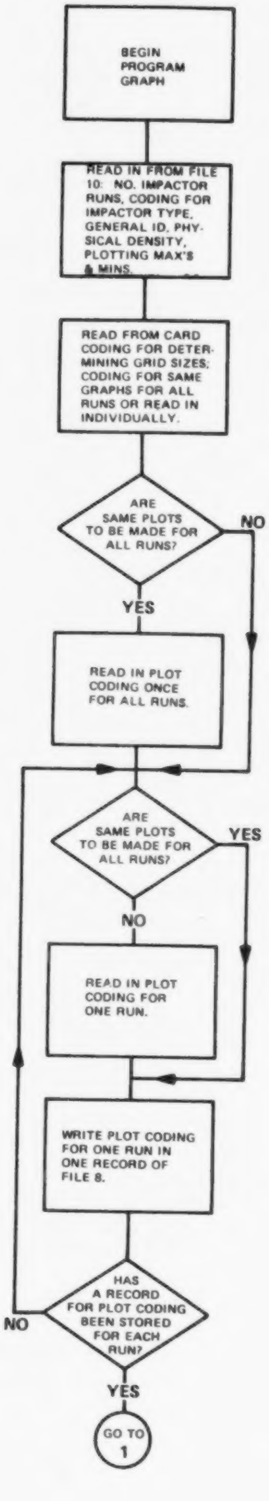
     1.      0.2500      93.2498         94.4870            92.0127
     2.      0.2947      84.4259         87.1595            81.6923
     3.      0.3474      87.0272         89.1122            84.9423
     4.      0.4095      92.3900         93.5582            91.2217
     5.      0.4827      95.1672         95.8692            94.4651
     6.      0.5690      95.9378         96.4654            95.4102
     7.      0.6707      95.7053         96.1838            95.2267
     8.      0.7906      95.1794         95.6560            94.7028
     9.      0.9319      94.7063         95.1633            94.2493
    10.      1.0985      94.6757         95.1040            94.2474
    11.      1.2949      95.2842         95.7126            94.8558
    12.      1.5264      96.4848         96.8712            96.0984
    13.      1.7992      97.8405         98.0882            97.5928
    14.      2.1209      98.5539         98.7183            98.3895
    15.      2.5000      98.7609         98.8906            98.6313
    16.      2.9469      98.7721         98.8930            98.6512
    17.      3.4737      98.5311         98.6656            98.3966
    18.      4.0947      98.1473         98.3042            97.9904
    19.      4.8267      97.6214         97.8088            97.4340
    20.      5.6896      97.3225         97.5439            97.1011
    21.      6.7067      96.5711         96.8522            96.2899
    22.      7.9057      96.6740         96.9464            96.4015
```

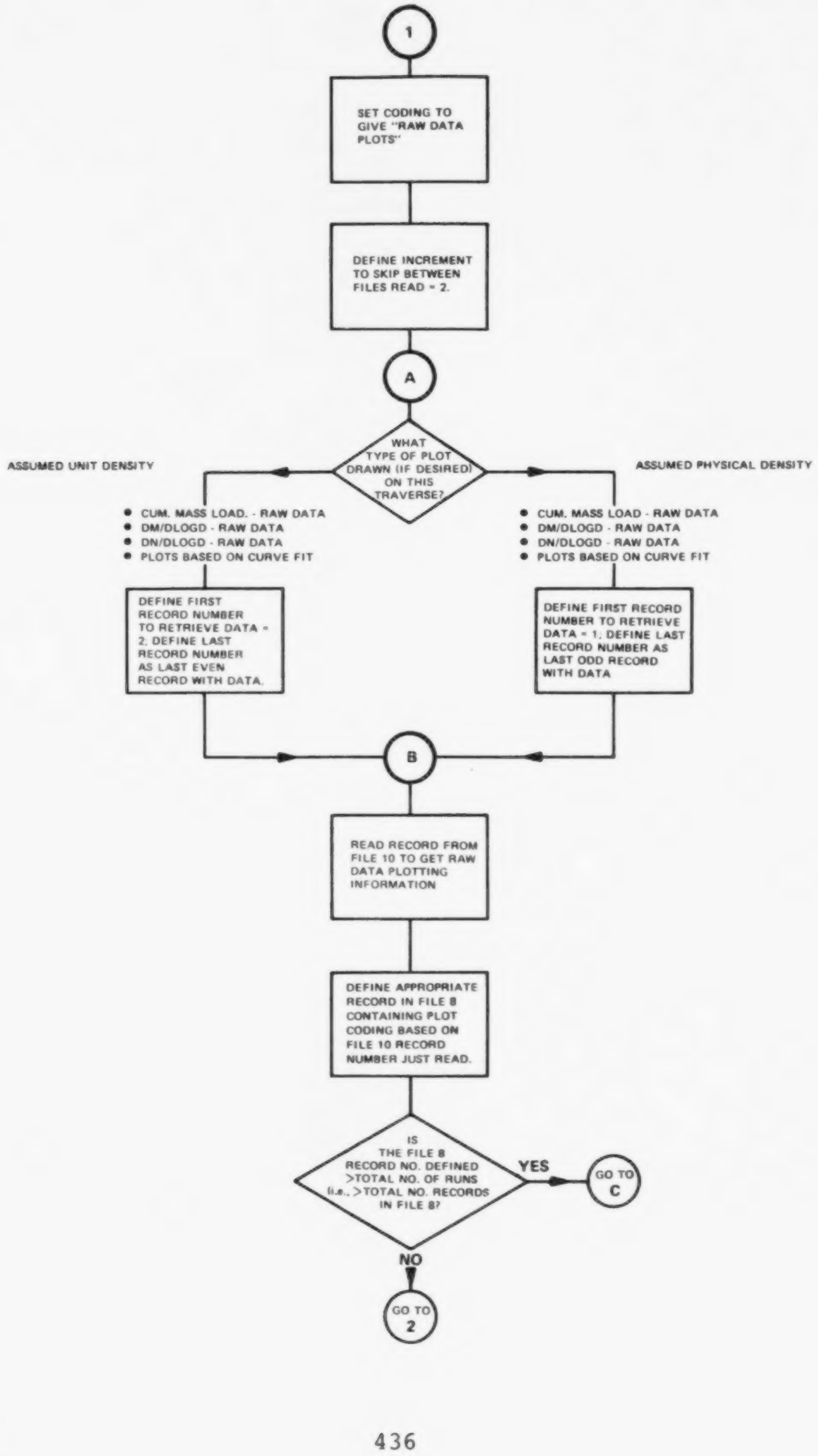

PENETRATION EFFICIENCY
CIDRS VERSION 1 TEST FOR PENETRATION-EFFICIENCY. PENLOG
RHO= 2.40 GM/CC
10^1
10^0
10^-1
10^-2
90.0
99.0
99.9
99.99
PERCENT PENETRATION
PERCENT EFFICIENCY
10^-1
10^0
10^1
10^2
PARTICLE DIAMETER (MICROMETERS)

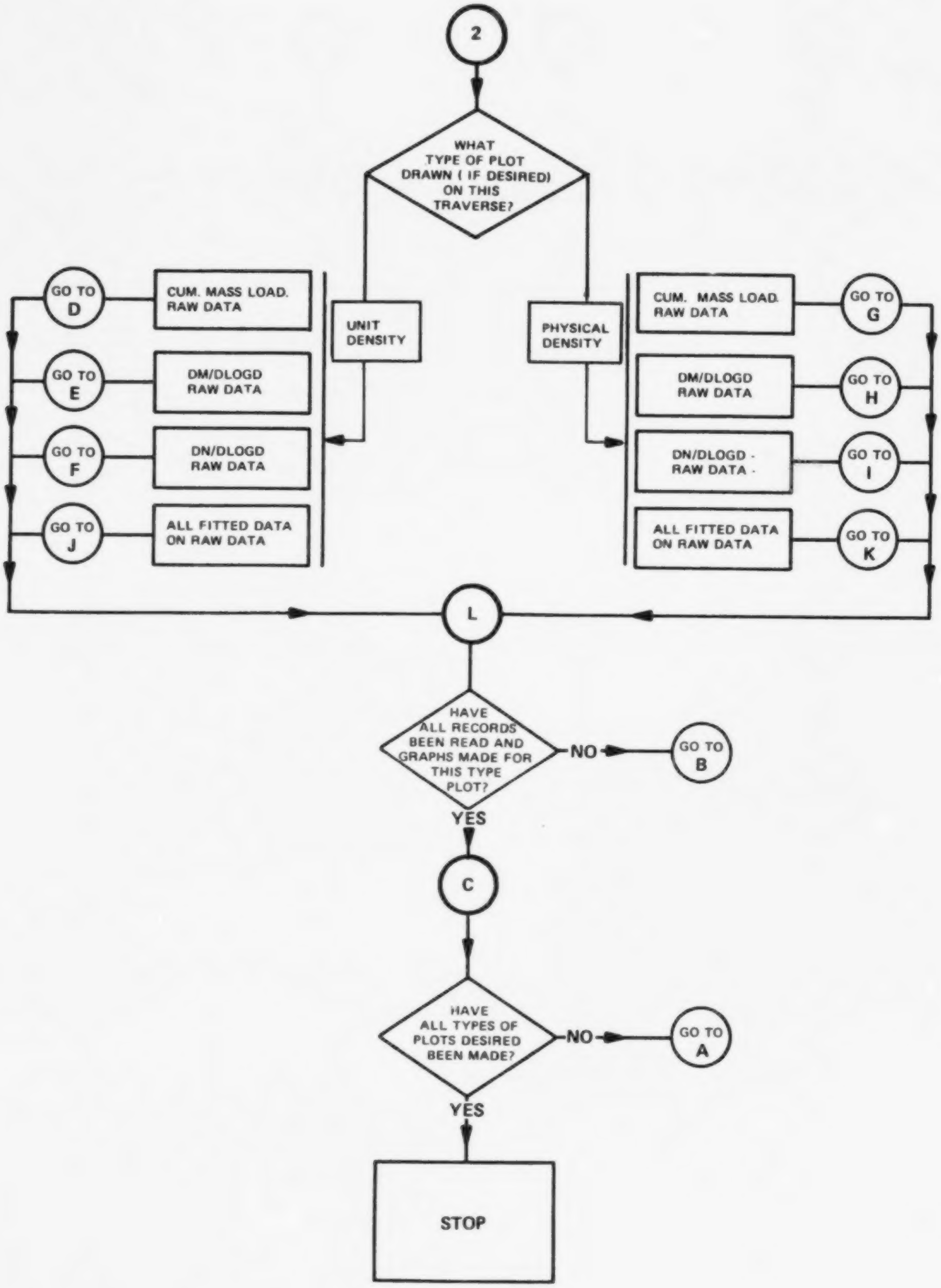
SECTION 6

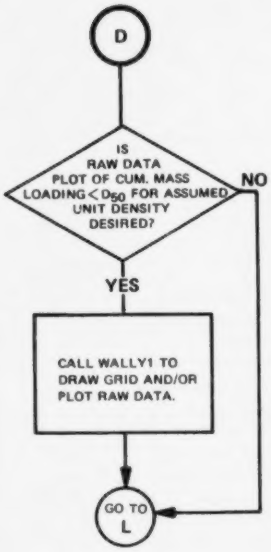
PROGRAM LISTINGS

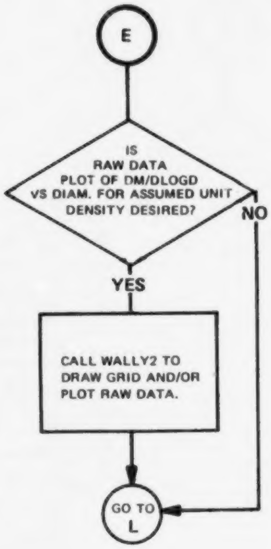
A source listing of each program in the cascade impactor data reduction system follows. The six mainline programs are first, arranged in alphabetical order. Before each of these programs is a simplified flowchart. Next are the subroutines and function subroutines, also arranged in alphabetical order. No flowcharts are provided for these.

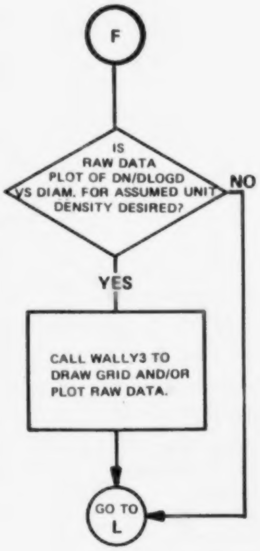

BEGIN PROGRAM GRAPH
READ IN FROM FILE 10: NO. IMPACTOR RUNS, CODING FOR IMPACTOR TYPE, GENERAL ID, PHYSICAL DENSITY, PLOTTING MAX'S & MINS.
READ FROM CARD CODING FOR DETERMINING GRID SIZES; CODING FOR SAME GRAPHS FOR ALL RUNS OR READ IN INDIVIDUALLY.
ARE SAME PLOTS TO BE MADE FOR ALL RUNS?
NO
YES
READ IN PLOT CODING ONCE FOR ALL RUNS.
ARE SAME PLOTS TO BE MADE FOR ALL RUNS?
YES
NO
READ IN PLOT CODING FOR ONE RUN.
WRITE PLOT CODING FOR ONE RUN IN ONE RECORD OF FILE 8.
HAS A RECORD FOR PLOT CODING BEEN STORED FOR EACH RUN?
NO
YES
GO TO 1

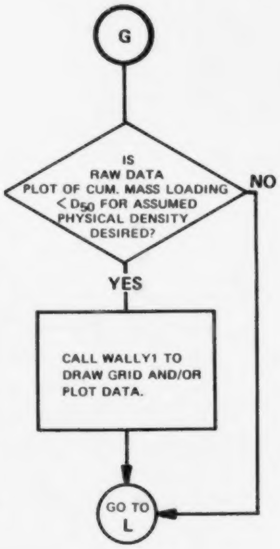

1
SET CODING TO GIVE "RAW DATA PLOTS"
DEFINE INCREMENT TO SKIP BETWEEN FILES READ = 2.
A
WHAT TYPE OF PLOT DRAWN (IF DESIRED) ON THIS TRAVERSE?
ASSUMED UNIT DENSITY
ASSUMED PHYSICAL DENSITY
• CUM. MASS LOAD. - RAW DATA
• DM/DLOGD - RAW DATA
• DN/DLOGD - RAW DATA
• PLOTS BASED ON CURVE FIT
• CUM. MASS LOAD - RAW DATA
• DM/DLOGD - RAW DATA
• DN/DLOGD - RAW DATA
• PLOTS BASED ON CURVE FIT
DEFINE FIRST RECORD NUMBER TO RETRIEVE DATA = 2; DEFINE LAST RECORD NUMBER AS LAST EVEN RECORD WITH DATA.
DEFINE FIRST RECORD NUMBER TO RETRIEVE DATA = 1; DEFINE LAST RECORD NUMBER AS LAST ODD RECORD WITH DATA
B
READ RECORD FROM FILE 10 TO GET RAW DATA PLOTTING INFORMATION
DEFINE APPROPRIATE RECORD IN FILE 8 CONTAINING PLOT CODING BASED ON FILE 10 RECORD NUMBER JUST READ.
IS THE FILE 8 RECORD NO. DEFINED >TOTAL NO. OF RUNS (i.e., >TOTAL NO. RECORDS IN FILE 8?
YES
GO TO C
NO
GO TO 2

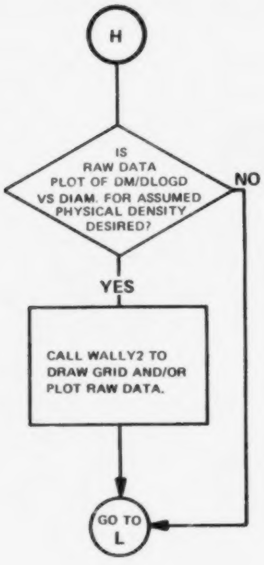

2
WHAT TYPE OF PLOT DRAWN (IF DESIRED) ON THIS TRAVERSE?
UNIT DENSITY
PHYSICAL DENSITY
CUM. MASS LOAD. RAW DATA
DM/DLOGD RAW DATA
DN/DLOGD RAW DATA
ALL FITTED DATA ON RAW DATA
GO TO D
GO TO E
GO TO F
GO TO J
CUM. MASS LOAD. RAW DATA
DM/DLOGD RAW DATA
DN/DLOGD - RAW DATA -
ALL FITTED DATA ON RAW DATA
GO TO G
GO TO H
GO TO I
GO TO K
L
HAVE ALL RECORDS BEEN READ AND GRAPHS MADE FOR THIS TYPE PLOT?
NO
GO TO B
YES
C
HAVE ALL TYPES OF PLOTS DESIRED BEEN MADE?
NO
GO TO A
YES
STOP

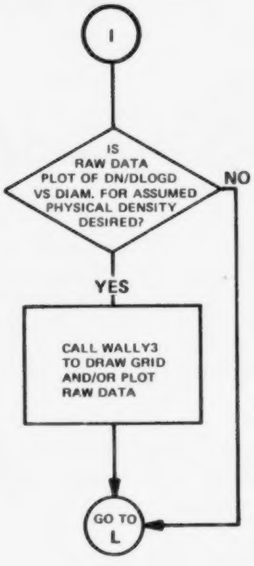

D
IS RAW DATA PLOT OF CUM. MASS LOADING < D_{50} FOR ASSUMED UNIT DENSITY DESIRED?
NO
YES
CALL WALLY1 TO DRAW GRID AND/OR PLOT RAW DATA.
GO TO L

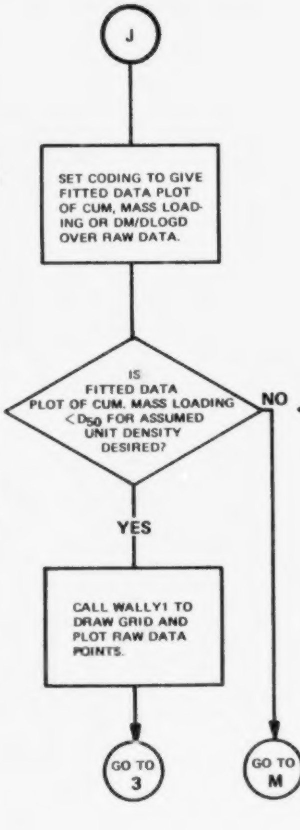

E
IS RAW DATA PLOT OF DM/DLOGD VS DIAM. FOR ASSUMED UNIT DENSITY DESIRED?
NO
YES
CALL WALLY2 TO DRAW GRID AND/OR PLOT RAW DATA.
GO TO L

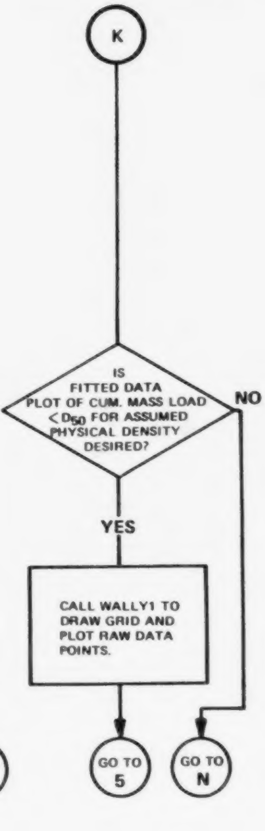

F
IS RAW DATA PLOT OF DN/DLOGD VS DIAM. FOR ASSUMED UNIT DENSITY DESIRED?
NO
YES
CALL WALLY3 TO DRAW GRID AND/OR PLOT RAW DATA.
GO TO L

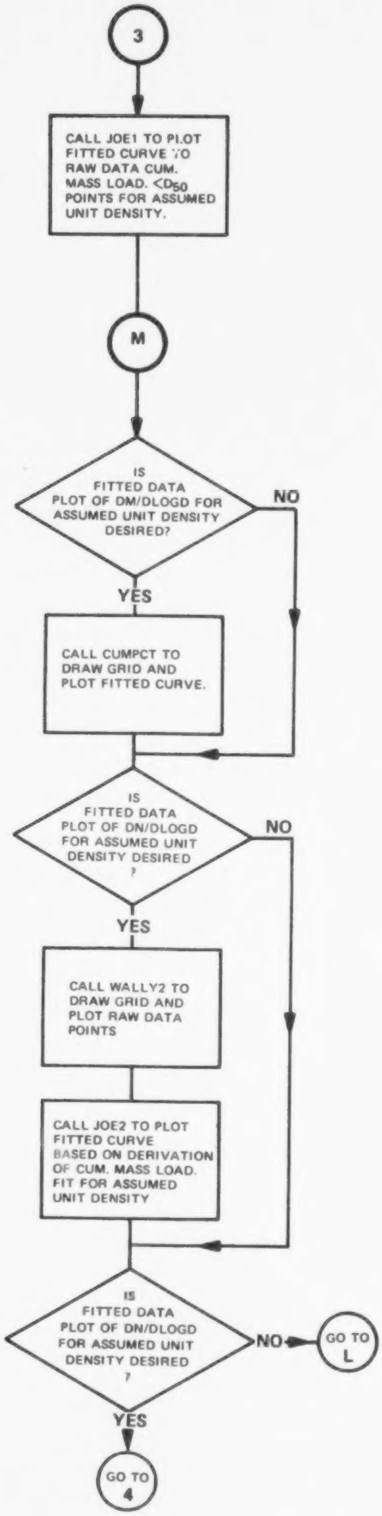

G
IS RAW DATA PLOT OF CUM. MASS LOADING < D_{50} FOR ASSUMED PHYSICAL DENSITY DESIRED?
NO
YES
CALL WALLY1 TO DRAW GRID AND/OR PLOT DATA.
GO TO L

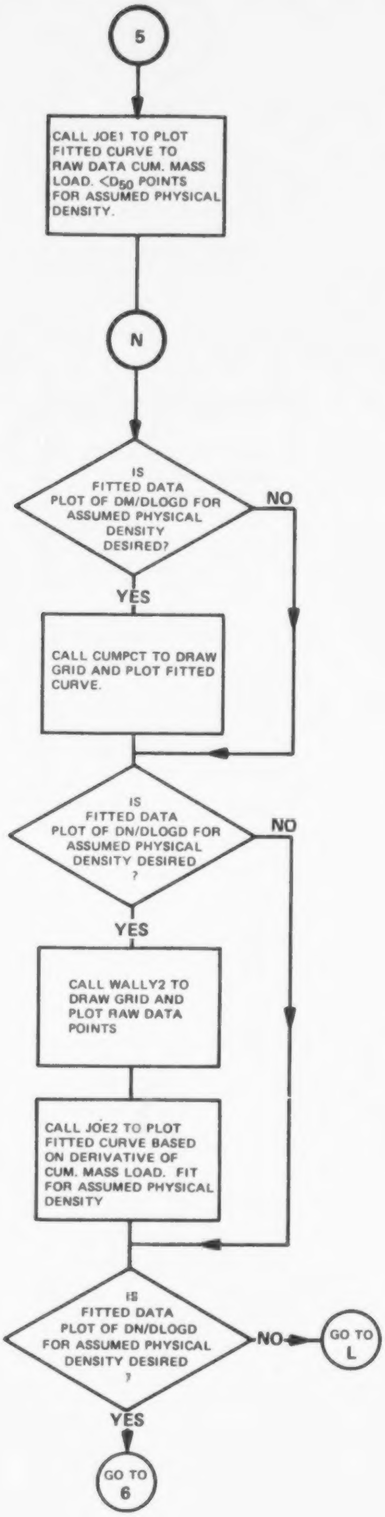

H
IS RAW DATA PLOT OF DM/DLOGD VS DIAM. FOR ASSUMED PHYSICAL DENSITY DESIRED?
NO
YES
CALL WALLY2 TO DRAW GRID AND/OR PLOT RAW DATA.
GO TO L

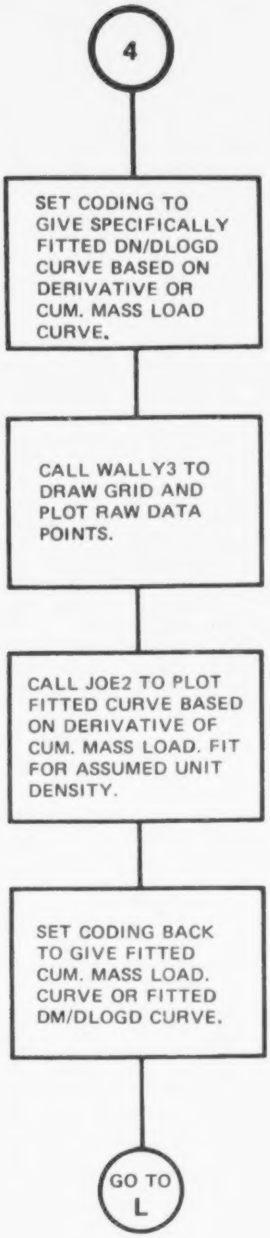

I
IS RAW DATA PLOT OF DN/DLOGD VS DIAM. FOR ASSUMED PHYSICAL DENSITY DESIRED?
NO
YES
CALL WALLY3 TO DRAW GRID AND/OR PLOT RAW DATA
GO TO L

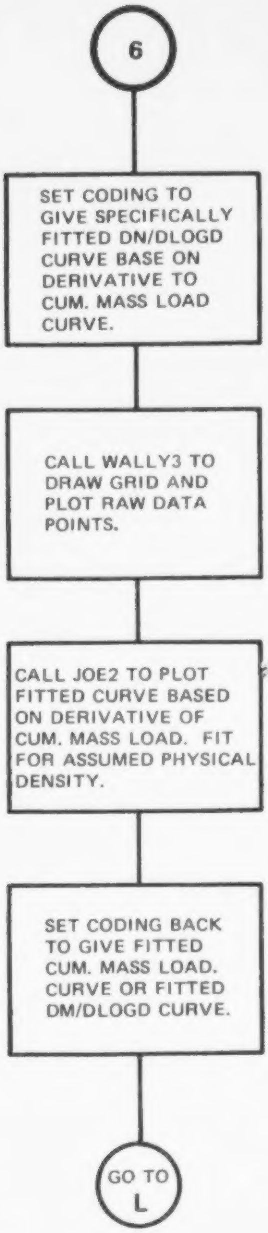

J
SET CODING TO GIVE FITTED DATA PLOT OF CUM. MASS LOADING OR DM/DLOGD OVER RAW DATA.
IS FITTED DATA PLOT OF CUM. MASS LOADING < D_{50} FOR ASSUMED UNIT DENSITY DESIRED?
NO
YES
CALL WALLY1 TO DRAW GRID AND PLOT RAW DATA POINTS.
GO TO 3
GO TO M


K
IS FITTED DATA PLOT OF CUM. MASS LOAD < D_{50} FOR ASSUMED PHYSICAL DENSITY DESIRED?
NO
YES
CALL WALLY1 TO DRAW GRID AND PLOT RAW DATA POINTS.
GO TO 5
GO TO N


3
CALL JOE1 TO PLOT FITTED CURVE TO RAW DATA CUM. MASS LOAD. <D50 POINTS FOR ASSUMED UNIT DENSITY.
M
IS FITTED DATA PLOT OF DM/DLOGD FOR ASSUMED UNIT DENSITY DESIRED?
NO
YES
CALL CUMPCT TO DRAW GRID AND PLOT FITTED CURVE.
IS FITTED DATA PLOT OF DN/DLOGD FOR ASSUMED UNIT DENSITY DESIRED ?
NO
YES
CALL WALLY2 TO DRAW GRID AND PLOT RAW DATA POINTS
CALL JOE2 TO PLOT FITTED CURVE BASED ON DERIVATION OF CUM. MASS LOAD. FIT FOR ASSUMED UNIT DENSITY
IS FITTED DATA PLOT OF DN/DLOGD FOR ASSUMED UNIT DENSITY DESIRED ?
NO
GO TO L
YES
GO TO 4


5
CALL JOE1 TO PLOT FITTED CURVE TO RAW DATA CUM. MASS LOAD. <D50 POINTS FOR ASSUMED PHYSICAL DENSITY.
N
IS FITTED DATA PLOT OF DM/DLOGD FOR ASSUMED PHYSICAL DENSITY DESIRED?
NO
YES
CALL CUMPCT TO DRAW GRID AND PLOT FITTED CURVE.
IS FITTED DATA PLOT OF DN/DLOGD FOR ASSUMED PHYSICAL DENSITY DESIRED ?
NO
YES
CALL WALLY2 TO DRAW GRID AND PLOT RAW DATA POINTS
CALL JOE2 TO PLOT FITTED CURVE BASED ON DERIVATIVE OF CUM. MASS LOAD. FIT FOR ASSUMED PHYSICAL DENSITY
IS FITTED DATA PLOT OF DN/DLOGD FOR ASSUMED PHYSICAL DENSITY DESIRED ?
NO
GO TO L
YES
GO TO 6


4
SET CODING TO GIVE SPECIFICALLY FITTED DN/DLOGD CURVE BASED ON DERIVATIVE OR CUM. MASS LOAD CURVE.
CALL WALLY3 TO DRAW GRID AND PLOT RAW DATA POINTS.
CALL JOE2 TO PLOT FITTED CURVE BASED ON DERIVATIVE OF CUM. MASS LOAD. FIT FOR ASSUMED UNIT DENSITY.
SET CODING BACK TO GIVE FITTED CUM. MASS LOAD. CURVE OR FITTED DM/DLOGD CURVE.
GO TO L


6
SET CODING TO GIVE SPECIFICALLY FITTED DN/DLOGD CURVE BASE ON DERIVATIVE TO CUM. MASS LOAD CURVE.
CALL WALLY3 TO DRAW GRID AND PLOT RAW DATA POINTS.
CALL JOE2 TO PLOT FITTED CURVE BASED ON DERIVATIVE OF CUM. MASS LOAD. FIT FOR ASSUMED PHYSICAL DENSITY.
SET CODING BACK TO GIVE FITTED CUM. MASS LOAD. CURVE OR FITTED DM/DLOGD CURVE.
GO TO L

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C     MAIN PROGRAM GRAPH
C***********************************************************************
C*    THIS MAINLINE IS USED AS A 'TRAFFIC DIRECTOR', THE INDIVIDUAL
C*    DATA RECORDS ARE READ SUPPLYING IDENTIFICATION CODING,
C*    EXPERIMENTAL DATA POINTS, AND COEFFICIENT VALUES FOR FITTING
C*    CUMULATIVE MASS LOADING DISTRIBUTION. CODES FOR PLOTTING
C*    INSTRUCTIONS ARE READ IN AND SUBROUTINES ARE CALLED TO PLOT
C*    ACCORDING TO THESE.
C***********************************************************************
C
      INTEGER VV
      DOUBLE PRECISION XNDPEN(10),YO(10)
      DIMENSION FILNAM(2),FGRAPH(2)
      DIMENSION IDALL(80),GEMAX(2),GEMIN(2),DMMAX(2),DMMIN(2),DNMAX(2)
      DIMENSION DNMIN(2),DPMAX(2),DPMIN(2),CUMAX(2),CUMIN(2),ID(80)
      DIMENSION DPC(8),CUMG(8),DMDLD(9),GEOMD(9),DNDLD(9)
      COMMON IMPAC,IDALL,RHO1,GEMAX,GEMIN,DMMAX,DMMIN,DNMAX,DNMIN
      COMMON DPMAX,DPMIN,CUMAX,CUMIN,ISIZ1,ISIZ2,ISIZ3
      COMMON IS,NFIT,ID,RHO,DMIN,TKS,POA,FG(5),DMAX,DPC,CUMG,DMDLD
      COMMON GEOMD,DNDLD,GRNAM,MPLOT,DSMA,VV
      COMMON ISIG,XMAX,XMIN,YMAX,YMIN,XS,YS
      COMMON CYC3,MC3,MOO,MS
      COMMON XNDPEN
      DATA FILNAM/'KMC00','1BIN'/
      DATA FGRAPH/'GRAPH','0BIN'/
      DATA IBLK/0/
      CALL DEFINE(10,251,101,FILNAM,I10,0,0,0)
      CALL DEFINE(8,15,50,FGRAPH,I10,0,0,0)
C
C     NRUN - NUMBER OF RUNS
C     IMPAC=1 - ANDERSEN IMPACTOR USED.
C          =2 - BRINK IMPACTOR USED.
C          =3 - UNIVERSITY OF WASHINGTON MARK III IMPACTOR USED.
C           =4 - MRI IMPACTOR USED.
C     IDALL - GENERAL IDENTIFICATION LABEL. USUALLY INCLUDES PLACE
C          AND DATE OF RUNS, INLET OR OUTLET ANNOTATION, AND RUN NUMBERS.
C     RHO1 - PHYSICAL DENSITY OF PARTICLES (GM/CC)
C
C     THE FOLLOWING ARE MAXIMUM AND MINUM VALUES OF ALL RUNS:
C
C     GEMAX,GEMIN - MAXIMUM,MINIMUM GEOMETRIC MEAN DIAMETER (MICRONS)
C     DMMAX,DMMIN - MAXIMUM,MINIMUM CHANGE IN MASS LOADING (MG/DNM3)
C     DNMAX,DNMIN - MAXIMUM,MINIMUM CHANGE IN NUMBER LOADING (NO./DNM3)
C     DPMAX,DPMIN - MAXIMUM,MINIMUM CUT POINT DIAMETER (MICRONS)
C     CUMAX,CUMIN - MAXIMUM,MINIMUM CUMULATIVE MASS LOADING (MG/ACM)
C
      READ(10'101)NRUN,IMPAC,IDALL,RHO1,GEMAX,GEMIN,DMMAX,DMMIN,DNMAX,
     1DNMIN,DPMAX,DPMIN,CUMAX,CUMIN
C
C
C     THE ISIZ1 VARIABLE IS CODING TO INDICATE WHETHER CUMULATIVE MASS
C     LOADING AND CUMULATIVE X MASS LOADING PLOTS ARE TO HAVE A STANDARD
C     RANGE AND NUMBER OF CYCLES (ISIZ1 = 0) OR WHETHER THESE ARE TO BE
C     DATA REGULATED (ISIZ1 = 1). ISIZ2 IS SIMILAR CODING FOR MASS SIZE
C     CONCENTRATION GRAPH; ISIZ3 IS SIMILAR CODING FOR NUMBER SIZE
C     CONCENTRATION GRAPH.
C
C     IREPET - CODING FOR READING IN GRAPH CODING VALUES MPLOT,J1,J2,...,
C     JP6 (SEE BELOW). IREPET = 0 - READ IN THESE VALUES ONCE AND LET
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C     THESE VALUES BE THE SAME FOR ALL RUNS TO BE PLOTTED. IREPET NOT =
C     0 - READ IN GRAPH CODING FOR EACH RUN (NRUN SETS OF GRAPH CODING).
C
      READ(2,900)ISIZ1,ISIZ2,ISIZ3,IREPET
C
C     MPLOT > 0 - MAKE NEW GRID FOR EACH 'RAW DATA' PLOT (CONTROLLED
C              BY J1 - J6).
C     MPLOT < 0 OR = 0 - PLOT SIMILAR TYPES OF 'RAW DATA' ON SAME GRID
C              AS PREVIOUS GRAPH.
C     FOR ALL GRAPH CODING LISTED BELOW:  0 - MAKE PLOT INDICATED
C                                       NOT = 0 - SUPPRESS PLOT
C
C     J1 - J3 APPLY TO GRAPHS WHERE AERODYNAMIC DENSITY IS ASSUMED:
C     J1 - 'RAW DATA' CUMULATIVE MASS LOADING VS. D50
C     J2 - 'RAW DATA' MASS SIZE CONCENTRATION VS. GEOM. MEAN DIAMETER
C     J3 - 'RAW DATA' NUMBER SIZE CONCENTRATION VS. GEOM. MEAN DIAMETER
C
C     J4 - J6 - AS FOR J1 - J3 RESPECTIVELY FOR ASSUMED PHYSICAL DENSITY
C
C     JP1 - JP3 ARE FOR GRAPHS WHERE AERODYNAMIC DENSITY IS ASSUMED:
C     JP1 - FITTED CUMULATIVE MASS LOADING DISTRIBUTION SUPERIMPOSED
C              ON A GRAPH OF THIS 'RAW DATA' .
C     JPCNT1 - FITTED CUMULATIVE % MASS LOADING DISTRIBUTION GRAPH
C     JP2 - MASS SIZE DISTRIBUTION FROM CUM. FIT SUPERIMPOSED ON A GRAPH
C              OF THIS 'RAW DATA'
C     JP3 - NUMBER SIZE DISTRIBUTION FROM CUM. FIT SUPERIMPOSED ON GRAPH
C              OF THIS 'RAW DATA'
C
C     JP4 - JP6 - AS FOR JP1 - JP3 RESPECTIVELY FOR ASSUMED PHYSICAL
C     DENSITY.
C
C     IF IREPET = 0, READ GRAPH CODING WHICH WILL APPLY TO ALL RUNS.
C
  600 IF(IREPET)602,601,602
  601 READ(2,902)MPLOT,J1,J2,J3,J4,J5,J6
      READ(2,902)JP1,JPCNT1,JP2,JP3,JP4,JPCNT4,JP5,JP6
C
C     THIS LOOP READS GRAPH CODING FOR EACH RUN (IF IREPET NOT = 0) AND/OR
C     STORES CODING FOR EACH RUN ON FILE.
C
  602 DO 650 L=1,NRUN
      IF(IREPET)605,615,605
  605 READ(2,902)MPLOT,J1,J2,J3,J4,J5,J6
      READ(2,902)JP1,JPCNT1,JP2,JP3,JP4,JPCNT4,JP5,JP6
  615 WRITE(8'L)MPLOT,J1,J2,J3,J4,J5,J6,JP1,JPCNT1,JP2,JP3,
     1JP4,JPCNT4,JP5,JP6
  650 CONTINUE
C
C     ISIG=0 - GIVES PLOTS OF 'RAW DATA' POINTS.
C     ISIG>0 - GIVES PLOTS OF FITTED CURVE ON TOP OF 'RAW DATA' POINTS.
C
 5600 ISIG=0
C
C     EVEN RECORDS ARE READ (DENSITY=1.0 GM/CC) FOR INDEX=1-3 AND 7.
C     ODD RECORDS ARE READ(DENSITY = PHYSICAL DENSITY) FOR INDEX = 4-6
C    AND 8. THUS:
C     ISTRT - FIRST RECORD = 1 FOR ODD RECORDS, = 2 FOR EVEN RECORDS
C     IEND - LAST RECORD
C
      DO 799 INDEX=1,8
      INC=2
      GO TO (710,710,710,720,720,720,710,720),INDEX
  710 ISTRT=2
      IEND=NRUN*2
      GO TO 730
  720 ISTRT=1
      IEND=(NRUN*2)-1
C
C     THE FOLLOWING LOOP CONTROLS CALLS TO SUBROUTINES WHICH PLOT.
C     ALSO, FOR INDEX = 7 OR 8,TABULAR LINE PRINT OUTPUT FOR
C     CUMULATIVE PERCENT PLC'S, DM/DLOGD PLOTS, AND DN/DLOGD PLOTS
C     RESULTING FROM FIT WILL BE PRINTED. WHEN 'J' VARIABLE USED,
C     'RAW DATA' ONLY IS PLOTTED. WHEN 'JP' VARIABLE USED, 'RAW DATA'
C     AND FITTED DATA PLOTTED. PLOT CONTROL VARIABLES (J1-J6,
C     JP1-JP6,JPCNT1,JPCNT4) VALUES ARE DETERMINED FROM READING FILE.
C     VARIABLE = 0 IF PLOT IS TO BE MADE, = 1 IF PLOT NOT TO BE MADE.
  730 DO 790 IAV=ISTRT,IEND,INC
C
C     BELOW ARE THE VARIABLES TO BE READ FROM FILE 10.
C     IS - RECORD AND RUN NUMBER. PROGRAM AT PRESENT
C     DESIGNED FOR 25 RUNS, EACH WITH CALCULATIONS FOR 2 DENSITIES.
C     THUS THERE CAN BE 50 RECORDS. ONE RECORD (RECORD 55) USED FOR
C     GENERAL ID AND OTHER INFORMATION APPLYING TO ALL RUNS.
C     NFIT - NUMBER OF DATA POINTS FROM CUMULATIVE MASS LOADING
C          CALCULATIONS TO BE FITTED.
C     GRNAM - MAXIMUM MASS LOADING (MG/ACM)
C     ID - IDENTIFICATION LABEL FOR THE RUN
C     RHO - DENSITY (GM/CC) = 1.0 FOR EVEN IS
C                           = PHYSICAL DENSITY FOR ODD IS
C     TTK - IMPACTOR TEMPERATURE (DEGREES KELVIN)
C     POA - GAS PRESSURE AT IMPACTOR INLET (ATMOSPHERES)
C     FGH2O - PERCENT WATER CONTENT OF GAS
C     DPC - CUT POINTS OF IMPACTOR STAGES (MICRONS)
C     CUMG - CUMULATIVE MASS LOADING AT EACH STAGE (MG/ACM)
C     DMDLD - CHANGE IN MASS LOADING AT EACH STAGE (MG/DNM3)
C     GEOMD - GEOMETRIC MEAN DIAMETER (MICRONS)
C     DNDLD - CHANGE IN NUMBER LOADING AT EACH STAGE (NO./DNM3)
C     GRNAM - MAXIMUM MASS LOADING (MG/ACM)
C     MPLOT - = 0 MAKE NEW PLOT FOR THESE CUM.,DM/DLD, AND DN/DLD PLOTS
C             = 1 SUPERIMPOSE DATA ON PREVIOUS PLOT
C     NOTE: CYC3 THROUGH MS APPLY ONLY WHEN IMPAC = 2 (I.E. WHEN USING
C     BRINK IMPACTOR). OTHERWISE ALL ZERO'S HAVE BEEN LOADED HERE.
C     CYC3 - APPROXIMATE MINIMUM PARTICLE DIAMETER (MICRONS) CAUGHT BY
C          CYCLONE (IF INCLUDED)
C     MC3 = 0 - CYCLONE USED
C         = 1 - CYCLONE NOT USED
C     M00 = 0 - STAGE 0 INCLUDED
C         = 1 STAGE 0 NOT INCLUDED
C     MS - LAST STAGE OF IMPACTOR, MS = EITHER 5 OR 6.
C     VV - ORIGINAL NUMBER OF POINTS FROM CUMULATIVE MASS LOADING
C          CALCULATIONS (MAY OR MAY NOT BE LESS THAN NFIT.)
C     XDPEN(I),I=1,NFIT - GEOMETRIC MEAN DIAMETERS (MICRONS) CORRESPONDING
C          TO YO(I),I=1,NFIT. (NOTE: THIS IS INDEPENDENT VARIABLE.
C     YO(I),I=1,NFIT - CUMULATIVE MASS LOADING VALUES (MG/ACM).
C
  800 READ(10'IAV)IS,NFIT,GRNAM,ID,RHO,TKS,POA,FG(5),DSMA,DMAX,
     1DPC,CUMG,DMDLD,GEOMD,DNDLD,CYC3,MC3,M00,MS,VV,
     2(XNDPEN(I),I=1,NFIT),(YO(I),I=1,NFIT)
      IREC=(IS+1)/2
      IF(IREC.GT.NRUN)GO TO 799
      READ(8'IREC)MPLOT,J1,J2,J3,J4,J5,J6,JP1,JPCNT1,JP2,JP3,
     1JP4,JPCNT4,JP5,JP6
C
C*********************************************************************
C      *     *           *            *                         *
C INDEX*ISIG *   MAJOR   *PLOT CONTROL*     RESULTING PLOT      *      DENSITY
C      *     *SUB'S USED*  VARIABLE   *                         *
C      *     *           *            *                         *
C*********************************************************************
C*********************************************************************
C      *     *           *            *                         *
C   1  * 0   *  WALLY1   *     J1     *CUMULATIVE MASS LOADING  *AERO.
C      *     *           *            * (MG/ACM AND GR/ACF)     *=1.0GM/CC
C      *     *           *            *           VS.           *
C      *     *           *            * PARTICLE DIAMETER       *
C      *     *           *            *      (MICRONS)          *
C      *     *           *            * OR CUMULATIVE MASS PLOT*
C      *     *           *            *                         *
C*********************************************************************
C      *     *           *            *                         *
C   2  * 0   *  WALLY2   *     J2     *CHANGE IN CUM. MASS LOAD* AERO.
C      *     *           *            *        (MG/DNM3)        *
C      *     *           *            *           VS.           *
C      *     *           *            *GEOMETRIC MEAN DIAMETER  *
C      *     *           *            *      (MICRONS)          *
C      *     *           *            *  (OR DM/DLOGD PLOT)     *
C      *     *           *            *                         *
C*********************************************************************
C      *     *           *            *                         *
C   3  * 0   *  WALLY3   *     J3     *CHANGE IN CUM. NO. LOAD. * AERO.
C      *     *           *            *       (NO./DNM3)        *
C      *     *           *            *           VS.           *
C      *     *           *            *GEOMETRIC MEAN DIAMETER  *
C      *     *           *            *      (MICRONS)          *
C      *     *           *            *  (OR DN/DLOGD PLOT)     *
C      *     *           *            *                         *
C*********************************************************************
C      *     *           *            *                         *
C   4  * 0   *  WALLY1   *     J4     *    CUMULATIVE MASS      *PHYSICAL
C      *     *           *            *                         *
C*********************************************************************
C      *     *           *            *                         *
C   5  * 0   *  WALLY2   *     J5     *        DM/DLOGD         *PHYSICAL
C      *     *           *            *                         *
C*********************************************************************
C      *     *           *            *                         *
C   6  * 0   *  WALLY3   *     J6     *        DN/DLOGD         *PHYSICAL
C      *     *           *            *                         *
C*********************************************************************
C
C
C     NOTE: FOR ANY OF THE INDEX NUMBERS 1 - 6, THERE MAY BE ONE PLOT
C     FOR EACH RUN IF MPLOT = 0; OR EACH PLOT MAY CONTAIN SEVERAL
C     DATA SETS SUPERIMPOSED IF MPLOT = 0 FOLLOWED BY MPLOT = 1 IN EACH
C     OF THE SUCCEEDING DATA FILES. DATA WILL BE SUPERIMPOSED ON THE
C     LAST PLOT WHERE MPLOT = 0. IT IS FOR THIS FLEXIBILITY THAT ALL
C     FILES ARE READ BEFORE CHANGING 'INDEX' FOR INDEX = 1-6. THERE'S
C     NO SUPERIMPOSITION FOR THE FOLLOWING PLOTS (INDEX = 7 AND 8). RESULT
C     WOULD BE CLUTTERED AND CONFUSING AS PLOT CONTAINS RAW DATA AND
C     FITTED DATA POINTS.
```
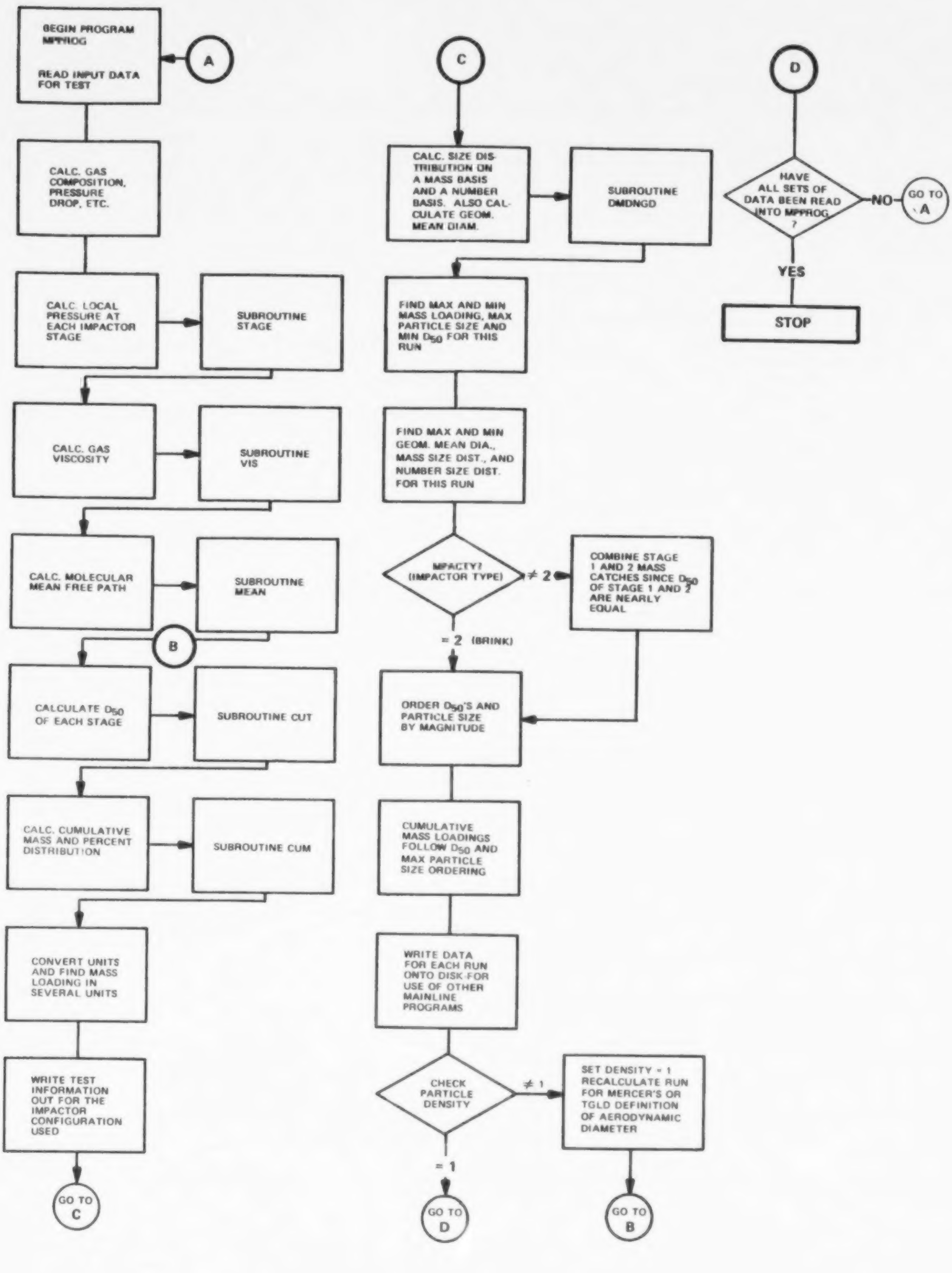

```
C
C
C      *     *          *             *                        *
C   7  * 1   *  WALLY1  *    JP1      *   CUMULATIVE MASS      *AERO.
C      *     *  JOE1    *             *                        *
C      *     *          *             *                        *
C************************************************************************
C      *     *          *             *                        *
C   7  * 1   *  CUMPCT  *   JPCNT1    *   CUMULATIVE PERCENT   *AERO.
C      *     *          *             *        MASS            *
C      *     *          *             *                        *
C************************************************************************
C      *     *          *             *                        *
C   7  * 1   *  WALLY2  *    JP2      *        DM/DLOGD        *AERO.
C      *     *  JOE2    *             *                        *
C      *     *          *             *                        *
C************************************************************************
C      *     *          *             *                        *
C   7  * 6   *  WALLY3  *    JP3      *        DN/DLOGD        *AERO.
C      *     *  JOE2    *             *                        *
C      *     *          *             *                        *
C************************************************************************
C      *     *          *             *                        *
C   8  * 1   *  WALLY1  *    JP4      *   CUMULATIVE MASS      *PHYSICAL
C      *     *  JOE1    *             *                        *
C      *     *          *             *                        *
C************************************************************************
C      *     *          *             *                        *
C   8  * 1   *  CUMPCT  *   JPCNT4    *   CUMULATIVE PERCENT   *PHYSICAL
C      *     *          *             *        MASS            *
C      *     *          *             *                        *
C************************************************************************
C      *     *          *             *                        *
C   8  * 1   *  WALLY2  *    JP5      *        DM/DLOGD        *PHYSICAL
C      *     *  JOE2    *             *                        *
C      *     *          *             *                        *
C************************************************************************
C      *     *          *             *                        *
C   8  * 6   *  WALLY3  *    JP6      *        DN/DLOGD        *PHYSICAL
C      *     *  JOE2    *             *                        *
C      *     *          *             *                        *
C************************************************************************
C
  810 GO TO (731,732,733,734,735,736,737,738),INDEX
  731 IF(J1.NE.IBLAK)GO TO 790
      CALL WALLY1
      GO TO 790
  732 IF(J2.NE.IBLAK)GO TO 790
      CALL WALLY2
      GO TO 790
  733 IF(J3.NE.IBLAK)GO TO 790
      CALL WALLY3
      GO TO 790
  734 IF(J4.NE.IBLAK)GO TO 790
      CALL WALLY1
      GO TO 790
  735 IF(J5.NE.IBLAK)GO TO 790
      CALL WALLY2
      GO TO 790
  736 IF(J6.NE.IBLAK)GO TO 790
```

```
      CALL WALLY3
      GO TO 790
  737 ISIG=1
      IF(JP1.NE.IBLAK)GO TO 740
      CALL WALLY1
  740 IF(JPCNT1.NE.IBLAK)GO TO 750
      CALL CUMPCT
  750 IF(JP2.NE.IBLAK)GO TO 751
      CALL WALLY2
  751 IF(JP3.NE.IBLAK)GO TO 790
      ISIG=6
      CALL WALLY3
      ISIG=1
      GO TO 790
  738 IF(JP4.NE.IBLAK)GO TO 755
      CALL WALLY1
  755 IF(JPCNT4.NE.IBLAK)GO TO 760
      CALL CUMPCT
  760 IF(JP5.NE.IBLAK)GO TO 761
      CALL WALLY2
  761 IF(JP6.NE.IBLAK)GO TO 790
      ISIG=6
      CALL WALLY3
      ISIG=1
  790 CONTINUE
  799 CONTINUE
  900 FORMAT(4I1)
  902 FORMAT(8I1)
 1000 STOP
      END
```


BEGIN PROGRAM MPPROG
READ INPUT DATA FOR TEST
A
CALC. GAS COMPOSITION, PRESSURE DROP, ETC.
CALC. LOCAL PRESSURE AT EACH IMPACTOR STAGE
SUBROUTINE STAGE
CALC. GAS VISCOSITY
SUBROUTINE VIS
CALC. MOLECULAR MEAN FREE PATH
SUBROUTINE MEAN
B
CALCULATE D50 OF EACH STAGE
SUBROUTINE CUT
CALC. CUMULATIVE MASS AND PERCENT DISTRIBUTION
SUBROUTINE CUM
CONVERT UNITS AND FIND MASS LOADING IN SEVERAL UNITS
WRITE TEST INFORMATION OUT FOR THE IMPACTOR CONFIGURATION USED
GO TO C
C
CALC. SIZE DISTRIBUTION ON A MASS BASIS AND A NUMBER BASIS. ALSO CALCULATE GEOM. MEAN DIAM.
SUBROUTINE DMDNGD
FIND MAX AND MIN MASS LOADING, MAX PARTICLE SIZE AND MIN D50 FOR THIS RUN
FIND MAX AND MIN GEOM. MEAN DIA., MASS SIZE DIST., AND NUMBER SIZE DIST. FOR THIS RUN
MPACTY? (IMPACTOR TYPE)
≠ 2
COMBINE STAGE 1 AND 2 MASS CATCHES SINCE D50 OF STAGE 1 AND 2 ARE NEARLY EQUAL
= 2 (BRINK)
ORDER D50'S AND PARTICLE SIZE BY MAGNITUDE
CUMULATIVE MASS LOADINGS FOLLOW D50 AND MAX PARTICLE SIZE ORDERING
WRITE DATA FOR EACH RUN ONTO DISK FOR USE OF OTHER MAINLINE PROGRAMS
CHECK PARTICLE DENSITY
≠ 1
SET DENSITY = 1 RECALCULATE RUN FOR MERCER'S OR TGLD DEFINITION OF AERODYNAMIC DIAMETER
= 1
GO TO D
GO TO B
D
HAVE ALL SETS OF DATA BEEN READ INTO MPPROG ?
NO
GO TO A
YES
STOP

```
C     MAIN PROGRAM MPPROG
C***********************************************************************
C*
C*       THIS IS A FORTRAN IV PROGRAM FOR CALCULATING STAGE CUT POINTS,
C*       (D50'S) AND THE PARTICLE SIZE DISTRIBUTION OF MATERIAL COL-
C*       LECTED BY A CASCADE IMPACTOR. COMMENT CARDS DESCRIBE THE INPUT
C*       AND OUTPUT DATA AND THE IMPORTANT CALCULATIONS. THE PROGRAM
C*       HANDLES ANDERSEN, BRINK, UNIVERSITY OF WASHINGTON, AND MRI
C*       IMPACTOR DATA.
C*
C***********************************************************************
C
      INTEGER X(8,4),VV
      REAL IMASS(9),ICUMM(9),MASS(9),MM,MU,L(8)
      DOUBLE PRECISION XNDPEN(10),YO(10),VARD(10),VARC(10)
      DIMENSION FILNAM(2),DPCON(5)
      COMMON/DUMMY/ID(80),PRCU(9),CUMG(8),CUMH(8),CUMI(8),CUMJ(8),
     1DPCF(50),DMAXX(50),CUMGF(50),CUMG1(50),GDMIN(50),
     2GDMAX(50),DMMN(50),DMMX(50),DNMN(50),DNMX(50),DPMIN(2),DPMAX(2),
     3CUMIN(2),CUMAX(2),GEMIN(2),GEMAX(2),DMMIN(2),DMMAX(2),DNMIN(2),
     4DNMAX(2),IDALL(80)
      COMMON/BLOCK1/PS(8),MU,POA,DPA,TCI,FG(5),DELP(8,4)
      COMMON/BLOCK2/TKI,MM,L,RHO,Q,DPC(8),CYC3,X,DC(8,6,4)
      COMMON/BLOCK3/MASS,F,DUR,TKS,CUMM(9),PERCU(9),
     1GRNA,GRNS,GRNAM,GRNSM
      COMMON/BLOCK4/RA,REYN1(7),REYN2(7),FD(7),MC3,MS,DMAX,GGRNS(9),M00,
     1DMDLD(9),DNDLD(9),GEOMD(9)
      COMMON/BLOCK5/NCUM,MPACTY,MPACNO,NMASS,MAERO
      DATA DPCON/1.287,3.783E02,3.928,1.093E03,9.375/
      DATA FILNAM/'KMC00','1BIN'/
      CALL DEFINE(10,251,101,FILNAM,I10,0,0,0)
C
C
C        READ CODE FOR IMPACTOR TYPE MPACTY AND CODE FOR AERODYNAMIC
C        DENSITY DEFINITION TO BE USED MAERO:
C        MPACTY = 1 - ANDERSEN
C               = 2 - BRINK
C               = 3 - UNIV. OF WASHINGTON (PILAT)
C               = 4 - METEOROLOGY RESEARCH, INC.  (MRI)
C        MAERO = 0 - CLASSIC DEFINITION OF AERODYNAMIC DENSITY
C              = 1 - MERCER'S DEFINITION
C
      READ(2,99)MPACTY,MAERO
C
C        NMASS = NO. OF MASSES TO BE READ = NO. OF STAGES + 1 FOR FILTER
C        + 1 FOR CYCLONE (IF APPLICABLE).
C
      NMASS=9
      IF (MPACTY.GE.3)NMASS=8
C
C        NCUM = NO. OF CUM. MASS LOADINGS < D50.
C
      NCUM=7
      IF(MPACTY.EQ.1)NCUM=8
C
C        READ GENERAL IDENTIFICATION LABEL IDALL. INFORMATION ON THIS
C        CARD PERTAINS TO ALL RUNS. MAY INCLUDE TEST SITE, DATE(S),
C        RUNNING CONDITIONS, ETC.  THIS WILL BE HEADING OF STATISTICAL
C        PRINT OUT AND GRAPHS IF PROGRAM STATIS IS RUN.
```

```
C
      READ(2,1004)IDALL
C
C         EACH RUN HAS THE THE CARD DATA SET TO FOLLOW. THERE ARE 6
C         CARDS FOR EACH RUN.
C
C
C     READ CODE FOR IMPACTOR NUMBER, MPACNO. EACH IMPACTOR IS
C     ASSIGNED A NUMBER SO THAT CALIBRATION CONSTANTS FOR
C     THIS IMPACTOR CAN BE STORED IN BLOCK DATA SUBROUTINES
C     COMBK1 AND COMBK2.
C
C
C
C
C
   12 READ(2,99)MPACNO
      IF(MPACNO)93,93,14
C
C         PO -- GAS PRESSURE AT IMPACTOR INLET.  INCHES OF MERCURY.
C         TFS -- TEMPERATURE OF STACK.   DEGREES FAHRENHEIT.
C         TFI -- TEMPERATURE OF IMPACTOR. DEGREES FAHRENHEIR.
C         RHO -- PARTICLE DENSITY.  GRAMS/CUBIC CENTIMETER.
C         DUR -- DURATION OF IMPACTOR SAMPLING.  MINUTES.
C         DMAX -- MAXIMUM DIAMETER OF MATERIAL COLLECTED.  MICRONS.
C        IF C3 USED, MC3=1; OTHERWISE, MC3=0.
C        IF S0 USED, M00=1; OTHERWISE, M00=0.
C        IF LAST STAGE IS S5(S6), MS=5(6).
C        IF BACK-UP FILTER USED, MF=1; OTHERWISE, MF=0.
C
   14 READ(2,300)PO,TFS,TFI,RHO,DUR,DMAX,MC3,M00,MS,MF
C
C         READ IN GAS COMPOSITION IN THIS ORDER--CO2(DRY)  CO(DRY)
C         N2(DRY)  O2(DRY)  H2O
C
      READ(2,102) (FG(I),I=1,5)
C
C         READ IN STAGE COLLECTIONS IN MILLIGRAMS IN THIS ORDER;
C         FILTER  STAGES(6,5,4,3,2,1,0)  C3 OR C2
C
      READ(2,106) (MASS(I),I=1,NMASS)
      DO 299 I=1,NMASS
      MASS(I)=MASS(I)/1000.0
  299 CONTINUE
C
C         READ IN IMPACTOR SAMPLING FLOW RATE IN ACFM.
C
      READ(2,310) F
C
C         READ IN TEST INFORMATION(DATE,TIME,ETC.) BETWEEN COLUMNS
C         2 TO 51.  PUT A 1 IN COLUMN 1.
C
      READ(2,1004)ID
C
C     NRUN IS INDEX FOR NUMBER OF RUNS READ.
C
      NRUN=NRUN+1
C
C     IF CALCULATIONS FOR BOTH DEFINITIONS OF AERODYNAMIC DIAMETER ARE
C     DESIRED, INPUT DENSITY RHO = 1.0 AND NAERO IS SET = 0 SO THAT
```

```
C      'TGLD' DEFINITION OF AERO. DIAMETER IS USED FOR 1ST COMPUTA-
C      TION OF D50'S, CUM. MASS LOADINGS, ETC. (MERCER'S DEFINITION OF
C      AERO. DIAMETER IS USED FOR 2ND COMPUTION. PHYSICAL DENSITY
C      COMPUTIONS NOT MADE.)
       NAERO=MAERO
       IF(RHO.EQ.1.) NAERO=0
C
C        CHANGE DRY GAS COMPOSITION TO WET.
C
       DO 251 I=1,4
       FG(I)=FG(I)*(1.0-FG(5))
  251 CONTINUE
C
C
C
C
C
C        MM IS THE AVERAGE MOLECULAR WEIGHT OF THE FLUE GAS.
C
       MM=44.10*FG(1)+28.01*FG(2)+28.02*FG(3)+32.00*FG(4)+18.02*FG(5)
C
C       CHANGE THE TEMPERATURE OF GAS IN THE IMPACTOR TO DEGREES CENTIGRADE.
C
       TCI=5.0*(TFI-32.0)/9.0
C
C       CHANGE THE TEMPERATURE OF GAS IN THE IMPACTOR TO DEGREES KELVIN.
C
       TKI=273.0+(5.0*(TFI-32.0)/9.0)
C
C       CHANGE THE TEMPERATURE OF GAS IN THE IMPACTOR TO DEGREES RANKINE.
C
       TRI=TFI+460.0
C
C       CHANGE THE TEMPERATURE OF GAS IN THE STACK TO DEGREES CENTIGRADE.
C
       TCS=5.0*(TFS-32.0)/9.0
C
C       CHANGE THE TEMPERATURE OF GAS IN THE STACK TO DEGREES KELVIN.
C
       TKS=273.0+(5.0*(TFS-32.0)/9.0)
C
C       CALCULATE THE FLOW RATE FOR IMPACTOR CONDITIONS IN ACFM.
C
       Q=F*(TKI/TKS)
C
C       CHANGE PO TO ATMOSPHERES.
C
       POA=PO/29.92
C
C       CALCULATE DROP IN PRESSURE ACROSS THE IMPACTOR IN INCHES OF
C       MERCURY.
C
       J=MPACTY
       IF(J.EQ.4)J=5
       IF(J.EQ.2.AND.MS.EQ.6)J=4
       DP=DPCON(J)*(Q*Q*PO)/TRI*MM/RA
C
C       CHANGE DP TO ATMOSPHERES.
C
       DPA=DP/29.92
```

```
C
C       THIS SUBROUTINE CALCULATES THE LOCAL PRESSURE AT EACH STAGE.
C
      CALL STAGE
C
C       THIS SUBROUTINE CALCULATES THE GAS VISCOSITY.
C
      CALL VIS
C
C       THIS SUBROUTINE CALCULATES THE MOLECULAR MEAN FREE PATH.
C
      CALL MEAN
      RHO1=1.0
 2010 CONTINUE
      IS=IS+1
      IF(RHO-1.0)2002,2002,2008
 2002 DMAX=DMAX*SQRT(RHO1)
C
C       THIS SUBROUTINE CALCULATES THE D50 OF EACH STAGE.
C
 2008 CALL CUT
C
C       THIS SUBROUTINE CALCULATES THE CUMULATIVE MASS AND CUMULATIVE
C       PERCENT DISTRIBUTION.
C
      CALL CUM
C
C       THIS LOOP CHANGES THE FLUE GAS COMPOSITION TO PERCENT.
C
 2011 DO 10 I=1,5
      FG(I)=FG(I)*100.0
 10   CONTINUE
C
C       THIS LOOP INVERTS THE ORDER OF THE MASS, CUMULATIVE MASS LOADING
C       < D50, AND CUMULATIVE PERCENT MASS LOADING < D50.
C
      NMASS1=NMASS+1
      DO 30 I=1,NMASS
      J=NMASS1-I
      IMASS(J)=MASS(I)
      PRCU(J)=PERCU(I)
      ICUMM(J)=CUMM(I)
   30 CONTINUE
C
C       THIS LOOP CHANGES MASS/STAGE FROM GRAMS TO MILLIGRAMS.
C
      DO 224 I=1,NMASS
      IMASS(I)=IMASS(I)*1000,0
      ICUMM(I)=ICUMM(I)*1000.0
  224 CONTINUE
      IF(MPACTY-2)501,502,501
  501 MLS=NCUM
      MMM=1
      GO TO 503
  502 MLS=MC3+M00+6
      MMM=3-(MC3+M00)
C
C       THIS LOOP CALCULATES CUMULATIVE MASS LOADING < STAGE D50 IN
C       MILLIGRAMS PER ACTUAL CUBIC METER(CUMG), GRAINS PER ACTUAL
C       CUBIC FOOT (CUMH), GRAINS PER DRY NORMAL CUBIC FOOT (CUMI).
```

```
C       AND MILLIGRAMS PER DRY NORMAL CUBIC METER (CUMJ).
C
  503 DO 504 I=1,MLS
      J=I+MMM
      FC=PRCU(J)/100.0
      CUMG(I)=GRNAM*FC
      CUMH(I)=GRNA*FC
      CUMI(I)=GRNS*FC
      CUMJ(I)=GRNSM*FC
  504 CONTINUE
C
C       THIS LOOP CALCULATES THE MILLIGRAMS PER DRY NORMAL CUBIC METER
C       PER STAGE.
C
      DO 505 I=1,NMASS
      GGRNS(I)=((IMASS(I)*15.4324)/((F*DUR*294.0*POA)/(TKS*1.0)))/((100.
     10-FG(5))/100.0)*2288.34/1000.0
  505 CONTINUE
C
C       THIS STATEMENT WRITES THE TEST INFORMATION.
C
      WRITE(3,1008)ID
C
C       THIS STATMENT WRITES THE IMPACTOR FLOW RATE , TEMPERATURE, SAMPLING
C       DURATION, PARTICLE DENSITY, STACK PRESSURE, AND MAXIMUM PARTICLE
C       DIAMETER.
C
      WRITE(3,201)F,TFI,TCI,DUR,DP,TFS,TCS,RHO,PO,DMAX
C
C       THIS STATEMENT WRITES THE FLUE GAS COMPOSITION, GRAINS PER ACTUAL
C       CUBIC FOOT, THE GRAINS PER NORMAL DRY CUBIC FOOT, THE
C       MILLIGRAMS PER ACTUAL CUBIC METER, THE MILLIGRAMS PER NORMAL
C       DRY CUBIC METER.
C
      WRITE(3,202) FG(1),FG(2),FG(3),FG(4),FG(5),GRNA,GRNS,GRNAM,GRNSM
C
C       STAGE COLUMN HEADINGS, D50'S, MASS/STAGE, MASS LOADING/STAGE,
C       % TOTAL MASS/STAGE, AND CUMULATIVE MASS DISTRIBUTION ARE WRITTEN.
C       FORMAT USED DEPENDS ON TYPE OF IMPACTOR.
C
      GO TO (3001,3100,3200,3200),MPACTY
C
C       THIS SECTION WRITES STAGE COLUMN HEADINGS, D50'S, MASS/STAGE,
C       MASS LOADING/STAGE, CUMULATIVE PERCENT MASS LOADING < STAGE
C       D50, AND CUMULATIVE MASS LOADING < STAGE D50 FOR ANDERSEN
C       IMPACTOR.
C
C
C       THIS STATEMENT WRITES THE D50'S FOR EACH STAGE.
C
 3001 WRITE(3,3203) (DPC(I),I=1,8)
C
C       THIS STATMENT WRITES THE MASS COLLECTED PER STAGE, THE MASS LOADING
C       PER STAGE, AND THE PERCENT OF THE TOTAL MASS ON EACH STAGE.
C
      WRITE(3,3113) (IMASS(I),I=1,9),(GGRNS(I),I=1,9),(PRCU(I+1),I=1,8)
C
C       THIS STATEMENT WRITES THE CUMULATIVE MASS LOADINGS IN MILLIGRAMS
C       PER ACTUAL CUBIC METER, MILLIGRAMS PER DRY NORMAL CUBIC METER,
C      GRAINS PER ACTUAL CUBIC FOOT, AND GRAINS PER DRY NORMAL CUBIC FOOT
```

```
C      , FOR EACH STAGE.
C
       WRITE(3,3114) (CUMG(I),I=1,8),(CUMJ(I),I=1,8),(CUMH(I),I=1,8),(CUM
      1I(I),I=1,8)
       GO TO 3300
 3100 M1=MS+M00
       M2=MS+MC3+M00
       M3=M2
       IF(MS-5)3110,3110,3105
 3105 M2=M2+1
 3110 CONTINUE
       IF(MC3.NE.1)GO TO 260
C
C         THIS SECTION WRITES STAGE COLUMN HEADINGS, D50'S, MASS/STAGE,
C         MASS LOADING/STAGE, CUMULATIVE PERCENT MASS LOADING < STAGE
C         D50, AND CUMULATIVE MASS LOADING < STAGE D50 FOR BRINK
C         IMPACTOR WHERE FIRST ''STAGE'' IS CYCLONE.
C
       IF(MS-5)400,400,500
C
C
C         THIS STATEMENT WRITES THE COLUMN HEADINGS FOR THE CYCLONE AND STAGES
C         S0,S1,S2,S3,S4,S5,SF,AND THE D50'S.
C
  400 WRITE(3,233)CYC3,(DPC(I),I=1,M1)
       GO TO 625
C
C         THIS STATEMENT WRITES THE COLUMN HEADINGS FOR THE CYCLONE AND STAGES
C         S0,S1,S2,S3,S4,S5,S6,SF,AND THE D50'S.
C
  500 WRITE(3,203)CYC3,(DPC(I),I=1,M1)
C
C         THIS STATEMENT WRITES THE MASS COLLECTED ON EACH STAGE.
C
  625 CONTINUE
       WRITE(3,220)
       WRITE(3,214) (IMASS(I),I=1,M2)
       IF(M2.EQ.7) WRITE(3,227) IMASS(9)
C
C         THIS STATEMENT WRITES THE GRAINS PER NORMAL DRY CUBIC FOOT PER STAGE
C
       IF(M2-7) 512,512,513
  512 WRITE(3,242) (GGRNS(I),I=1,M2),GGRNS(9)
       GO TO 514
  513 WRITE(3,204) (GGRNS(I),I=1,9)
C
C         THIS STATEMENT WRITES THE CUMULATIVE PERCENT OF MASS < D50.
C
  514 WRITE(3,215) (PRCU(I+1),I=1,M3)
C
C         THIS STATEMENT WRITES THE CUMULATIVE MASS IN MILLIGRAMS PER ACTUAL
C         CUBIC METER SMALLER THAN D50.
C
       WRITE(3,210)
       WRITE(3,221) CUMG(1)
       WRITE(3,223) (CUMG(I+1),I=1,M1)
C
C         THIS STATMENT WRITES THE CUMULATIVE MASS IN MILLIGRAMS PER DRY
C         DRY CUBIC METER.
C
```

```
      WRITE(3,217)
      WRITE(3,221) CUMJ(1)
      WRITE(3,223) (CUMJ(I+1),I=1,M1)
C
C       THIS STATEMENT WRITES THE CUMULATIVE MASS IN GRAINS PER ACTUAL
C       CUBIC FOOT SMALLER THAN D50.
C
      WRITE(3,219)
      WRITE(3,221) CUMH(1)
      WRITE(3,223) (CUMH(I+1),I=1,M1)
C
C       THIS STATEMENT WRITES THE CUMULATIVE MASS IN GRAINS PER DRY NORMAL
C       CUBIC FOOT SMALLER THAN D50.
C
      WRITE(3,235)
      WRITE(3,221) CUMI(1)
      WRITE(3,223) (CUMI(I+1),I=1,M1)
      GO TO 3300
  260 IF(M00.NE.1) GO TO 261
C
C       THIS SECTION WRITES STAGE COLUMN HEADINGS, D50'S, MASS/STAGE,
C       MASS LOADING/STAGE, CUMULATIVE PERCENT MASS LOADING < STAGE
C       D50, AND CUMULATIVE MASS LOADING < STAGE D50 FOR BRINK
C       IMPACTOR WHERE FIRST STAGE = STAGE 0.
C
      IF(M8-5) 410,410,520
C
C
C       THIS STATEMENT WRITES THE COLUMN HEADINGS FOR STAGES S0,S1,S2,S3,
C       S4,S5,SF.
C
  410 WRITE(3,234)
      GO TO 421
C
C       THIS STATEMENT WRITES THE COLUMN HEADINGS FOR STAGES S0,S1,S2,S3,
C       S4,S5,S6,SF
C
  520 WRITE(3,205)
C
C       THIS STATEMENT WRITES THE D50'S.
C
  421 WRITE(3,209) (DPC(I),I=1,M1)
C
C       THIS STATEMENT WRITES THE MASS COLLECTED ON EACH STAGE.
C
      WRITE(3,220)
      WRITE(3,222) (IMASS(I+1),I=1,M2)
      IF(M2.EQ.6) WRITE(3,227) IMASS(9)
C
C       THIS STATEMENT WRITES THE GRAINS PER NORMAL DRY CUBIC FOOT PER
C       STAGE.
C
      IF(M2-6) 422,422,423
  422 WRITE(3,207) (GGRNS(I+1),I=1,M2),GGRNS(9)
      GO TO 424
  423 WRITE(3,206) (GGRNS(I+1),I=1,8)
C
C       THIS STATEMENT WRITES THE CUMULATIVE PERCENT OF MASS SMALLER THAN
C       THE D50.
C
```

```
  424 WRITE(3,208) (PRCU(I+2),I=1,M3)
C
C       THIS STATEMENT WRITES THE CUMULATIVE MASS IN MILLIGRAMS PER ACTUAL
C       CUBIC METER SMALLER THAN D50.
C
      WRITE(3,210)
      WRITE(3,218) (CUMG(I),I=1,M1)
C
C       THIS STATMENT WRITES THE CUMULATIVE MASS IN MILLIGRAMS PER DRY
C       DRY CUBIC METER.
C
      WRITE(3,217)
      WRITE(3,218) (CUMJ(I),I=1,M1)
C
C       THIS STATEMENT WRITES THE CUMULATIVE MASS IN GRAINS PER ACTUAL
C       CUBIC FOOT SMALLER THAN D50.
C
      WRITE(3,219)
      WRITE(3,218) (CUMH(I),I=1,M1)
C
C       THIS STATEMENT WRITES THE CUMULATIVE MASS IN GRAINS PER DRY NORMAL
C       CUBIC FOOT SMALLER THAN D50.
C
      WRITE(3,235)
      WRITE(3,218) (CUMI(I),I=1,M1)
      GO TO 3300
C
C       THIS SECTION WRITES STAGE COLUMN HEADINGS, D50'S, MASS/STAGE,
C       MASS LOADING/STAGE, CUMULATIVE PERCENT MASS LOADING < STAGE
C       D50, AND CUMULATIVE MASS LOADING < STAGE D50 FOR BRINK
C       IMPACTOR WHERE FIRST STAGE = STAGE 1.
C
  261 IF(M8-5) 430,430,530
C
C       THIS STATEMENT WRITES THE COLUMN HEADINGS FOR THE STAGES S1,S2,S3,
C       S4,S5,SF.
C
  430 WRITE(3,239)
      GO TO 441
C
C       THIS STATEMENT WRITES THE COLUMN HEADINGS FOR THES STAGES S1,S2,S3,
C       S4,S5,S6,SF.
  530 WRITE(3,240)
C
C
C       THIS STATEMENT WRITES THE D50'S.
C
  441 WRITE(3,236) (DPC(I+1),I=1,M1)
C
C       THIS STATEMENT WRITES THE MASS COLLECTED ON EACH STAGE.
C
      WRITE(3,220)
      WRITE(3,225) (IMASS(I+2),I=1,M2)
      IF(M2.EQ.5) WRITE(3,227) IMASS(9)
C
C       THIS STATEMENT WRITES THE GRAINS PER NORMAL DRY CUBIC FOOT PER
C       STAGE.
C
      IF(M2-5) 442,442,443
  442 WRITE(3,237) (GGRNS(I+2),I=1,M2),GGRNS(9)
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```
      GO TO 444
  443 WRITE(3,238) (GGRNS(I+2),I=1,6),GGRNS(9)
C
C        THIS STATEMENT WRITES THE CUMULATIVE PERCENT OF MASS < D50.
C
  444 WRITE(3,241) (PRCU(I+3),I=1,M3)
C
C        THIS STATEMENT WRITES THE CUMULATIVE MASS IN MILLIGRAMS PER ACTUAL
C        CUBIC METER SMALLER THAN D50.
C
      WRITE(3,210)
      WRITE(3,226) (CUMG(I),I=1,M1)
C
C
C        THIS STATMENT WRITES THE CUMULATIVE MASS IN MILLIGRAMS PER DRY
C        DRY CUBIC METER.
C
      WRITE(3,217)
      WRITE(3,226) (CUMJ(I),I=1,M1)
C
C        THIS STATEMENT WIRTES THE CUMULATIVE MASS IN GRAINS PER ACTUAL
C        CUBIC FOOT SMALLER THAN D50.
C
      WRITE(3,219)
      WRITE(3,226) (CUMH(I),I=1,M1)
C
C        THIS STATEMANT WRITES THE CUMULATIVE MASS IN GRAINS PER DRY STANDARD
C        CUBIC FOOT SMALLER THAN D50.
C
      WRITE(3,235)
      WRITE(3,226) (CUMI(I),I=1,M1)
      GO TO 3300
C
C        THIS SECTION WRITES STAGE COLUMN HEADINGS, D50'S, MASS/STAGE,
C        MASS LOADING/STAGE, CUMULATIVE PERCENT MASS LOADING < STAGE
C        D50, AND CUMULATIVE MASS LOADING < STAGE D50 FOR UNIVERSITY
C       OF WASHINGTON (PILAT) IMPACTOR OR FOR MRI IMPACTOR.
C
C
C        THIS STATEMENT WRITES THE D50'S FOR EACH STAGE.
C
 3200 WRITE(3,6203) (DPC(I),I=1,7)
C
C        THIS STATMENT WRITES THE MASS COLLECTED PER STAGE, THE MASS LOADING
C        PER STAGE, AND THE PERCENT OF THE TOTAL MASS ON EACH STAGE.
C
      WRITE(3,6113) (IMASS(I),I=1,8),(GGRNS(I),I=1,8),(PRCU(I+1),I=1,7)
C
C        THIS STATEMENT WRITES THE CUMULATIVE MASS LOADINGS IN MILLIGRAMS
C        PER ACTUAL CUBIC METER, MILLIGRAMS PER DRY NORMAL CUBIC METER,
C       GRAINS PER ACTUAL CUBIC FOOT, AND GRAINS PER DRY NORMAL CUBIC FOOT
C      , FOR EACH STAGE.
      WRITE(3,6114) (CUMG(I),I=1,7),(CUMJ(I),I=1,7),(CUMH(I),I=1,7),(CUM
     1I(I),I=1,7)
C
 3300 CONTINUE
C
C       THIS SUBROUTINE CALCULATES THE SIZE DISTRIBUTION ON A MASS BASIS.
C
      CALL DMDNGD
```

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C
C       WRITE NORMAL (ENGINEERING STANDARD) CONDITIONS.
C
      WRITE(3,243)
C
C       IF MAKING CALCULATIONS FOR ASSUMED AERODYNAMIC DENSITY, THIS
C       SECTION WRITES WHETHER 'TGLD' OR MERCER DEFINITION USED.
C
      IF(RHO-1.0)3305,3305,3320
 3305 IF(NAERO)3310,3310,3315
 3310 WRITE(3,244)
      GO TO 3320
 3315 WRITE(3,245)
 3320 CONTINUE
C
C       FIND MAXIMUM AND MINIMUM CUMULATIVE MASS LOADINGS (CUMG1(IS)
C       AND CUMGF(IS), RESPECTIVELY), MAXIMUM PARTICLE SIZE (DMAXX(IS)),
C       AND MINIMUM D50 (DPCF(IS)) FOR THIS RUN, NC = NO. OF CUM.
C       MASS LOADINGS TO BE CHECKED, ND = NO. OF D50'S TO BE CHECKED.
C
      IF(MPACTY-2)3360,3370,3360
 3360 NC=NCUM
      ND=NCUM
      GO TO 3400
 3370 NC=M1+MC3
      ND=M1
 3400 NC1=NC+1
      ND1=ND+1
      IF(MPACTY.EQ.2.AND.M00.EQ.0)ND1=ND1+1
      DO 3500 J=1,NC
      K=NC1-J
      CUMGF(IS)=CUMG(K)
      IF(CUMGF(IS))3500,3500,3550
 3500 CONTINUE
 3550 CUMG1(IS)=GRNAM
      DO 3570 J=1,ND
      K=ND1-J
      DPCF(IS)=DPC(K)
      IF(DPCF(IS))3570,3570,3575
 3570 CONTINUE
 3575 DMAXX(IS)=DMAX
C
C       FIND MAXIMUM AND MINIMUM GEOMETRIC MEAN DIAMETERS (GDMAX(IS),
C       GDMIN(IS)), MASS SIZE DISTRIBUTION VALUES (DMMX(IS),DMMN(IS)),
C       AND NO. SIZE DISTRIBUTION VALUES (DNMX(IS),DNMN(IS)) FOR THIS
C       RUN.
C
      DO 4000 J=1,NMASS
      K=NMASS+1-J
      GDMIN(IS)=GEOMD(K)
      IF(GDMIN(IS).GT.0.0)GO TO 4030
 4000 CONTINUE
 4030 GDMAX(IS)=GEOMD(1)
      DO 4100 J=1,NMASS
      DMMN(IS)=DMDLD(J)
      IF(DMMN(IS).GT.0.0)GO TO 4130
 4100 CONTINUE
 4130 LL=J+1
      DO 4150 I=LL,NMASS
      IF(DMDLD(I).LT.DMMN(IS).AND.DMDLD(I).GT.0.0)DMMN(IS)=DMDLD(I)
 4150 CONTINUE
 4160 DMMX(IS)=DMDLD(1)
      DO 4175 LL=2,NMASS
      IF(DMDLD(LL).GT.DMMX(IS))DMMX(IS)=DMDLD(LL)
 4175 CONTINUE
      DO 4200 J=1,NMASS
      DNMN(IS)=DNDLD(J)
      IF(DNMN(IS).GT.0.0)GO TO 4230
 4200 CONTINUE
 4230 LL=J+1
      DO 4250 I=LL,NMASS
      IF(DNDLD(I).LT.DNMN(IS).AND.DNDLD(I).GT.0.0)DNMN(IS)=DNDLD(I)
 4250 CONTINUE
 4260 DNMX(IS)=DNDLD(1)
      DO 4275 LL=2,NMASS
      IF(DNDLD(LL).GT.DNMX(IS))DNMX(IS)=DNDLD(LL)
 4275 CONTINUE
C
C         VARD IS SET OF DMAX, CYC3 (IF BRINK AND CYCLONE USED), D50(1),
C         D50(2),.....,D50(LAST STAGE) IN THIS ORDER.
C         VARC IS SET OF TOTAL MASS LOADING, MASS LOADING < CYC3 (IF BRINK
C         AND CYCLONE USED), MASS LOADING < D50(1),.....,MASS LOADING <
C         D50(LAST STAGE) IN THIS ORDER. VV = NUMBER OF VARD AND VARC
C         VALUES.
C
      VARD(1)=DMAX
      VARC(1)=GRNAM
      GO TO (6300,6350,6375,6375),MPACTY
C
C         THE D50'S OF STAGES 1 AND 2 OF THE ANDERSEN, U. OF W.,
C         AND MRI IMPACTOR ARE VERY CLOSE, THEREFORE, THE FITTING
C         PROGRAM IS SET TO IGNORE D50 AND
C         CUM. MASS LOADING OF SECOND STAGE.
C
 6300 DO 6320 I=2,8
      J=I
      IF(I.EQ.2) J=1
      VARD(I)=DPC(J)
      VARC(I)=CUMG(J)
 6320 CONTINUE
      VV=8
      GO TO 6400
 6350 M01=1
      IF(MC3-1)6011,6010,6010
 6010 VV=9
      VARD(2)=CYC3
      GO TO 6017
 6011 IF(M00-1)6016,6012,6012
 6012 VV=8
      VARD(2)=DPC(1)
      GO TO 6017
 6016 VV=7
      VARD(2)=DPC(2)
 6017 IF(MS-5)6031,6031,6032
 6031 VV=VV-1
 6032 NT=4-(MC3+M00+M01)
      VARC(2)=CUMG(1)
      DO 6035 I=3,VV
      VARD(I)=DPC(NT)
      VARC(I)=CUMG(I-1)
      NT=NT+1
 6035 CONTINUE
      GO TO 6400
 6375 DO 6390 I=2,7
      J=I
      IF(I.EQ.2) J=1
      VARD(I)=DPC(J)
      VARC(I)=CUMG(J)
 6390 CONTINUE
      VV=7
C
C        CHECK FOR 0 VALUES IN VARD AND VARC, SET NON 0 VALUES = XNDPEN
C        AND YO VALUES, RESPECTIVELY. FINAL VALUE OF NFIT IS NUMBER OF
C        (XNDPEN,YO) POINTS TO BE FITTED IN SPLIN1.
C
 6400 J=1
      IF(MF.EQ.0)VV=VV-1
      NFIT=VV
      DO 6050 I=1,VV
      IF(VARD(I)*VARC(I))6042,6042,6044
 6042 NFIT=NFIT-1
      GO TO 6050
 6044 XNDPEN(J)=VARD(I)
      YO(J)=VARC(I)
      J=J+1
 6050 CONTINUE
C
C        IN THESE 2 LOOPS, INVERT ORDER OF XNDPEN AND YO I.E. NOW
C        (XNDEPN,YO)1 IS D50 OF LAST STAGE AND CUM. MASS LOADING < THIS
C        D50.
C
      DO 6070 I=1,NFIT
      J=NFIT+1-I
      VARD(I)=XNDPEN(J)
 6070 VARC(I)=YO(J)
      DO 6080 I=1,NFIT
      XNDPEN(I)=VARD(I)
 6080 YO(I)=VARC(I)
C
C        ORDER XNDPEN (I.E. D50'S AND MAX. PARTICLE SIZE) BY MAGNITUDE.
C        YO ORDERING FOLLOWS XNDPEN ORDERING. ORDERING OF (XNDPEN,YO)
C        SHOULD REMAIN SAME EXCEPT FOR UNIV. OF WASHINGTON STAGES 1
C        AND 2 (D50(2) > D50(1)).
C
      NFIT1=NFIT-1
      DO 6082 J=1,NFIT1
      K=NFIT-J
      DO 6082 I=1,K
      LL=I+1
      IF(XNDPEN(I)-XNDPEN(LL))6082,6082,6081
 6081 TEMP=XNDPEN(LL)
      XNDPEN(LL)=XNDPEN(I)
      XNDPEN(I)=TEMP
      TEMP=YO(LL)
      YO(LL)=YO(I)
      YO(I)=TEMP
 6082 CONTINUE
C
C        DSMA = SMALLEST D50 FOR THIS RUN.
C
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      DSMA=XNDPEN(1)
C
C       JV = NO. OF CUM. MASS LOADING VS. D50 VALUES + 1 FOR MAX.
C       PARTICLE DIAMETER VS. TOTAL MASS LOADING. (MAY BE > NFIT.)
C
      JV=8
      IF(MPACTY.EQ.3.OR.MPACTY.EQ.4)JV=7
C
C       THE STATEMENT WRITES THE SEPERATE IMPACTOR RUNS ON A DISK UNIT FOR
C       FURTHER MANIPULATION OF DATA IN THE SUBSEQUENT MAINLINE
C     PROGRAMS SPLIN1 AND GRAPH.
C
      WRITE(10'IS)IS,NFIT,GRNAM,ID,RHO,TKS,POA,FG(5),DSMA,DMAX,
     1DPC,CUMG,DMDLD,GEOMD,DNDLD,CYC3,MC3,M00,MS,
     2JV,(XNDPEN(I),I=1,NFIT),(VO(I),I=1,NFIT)
C
C           CHANGE PERCENT GAS COMPOSITION TO FRACTIONAL GAS COMPOSITION.
C
      DO 2030 I=1,5
      FG(I)=FG(I)/100.0
 2030 CONTINUE
C
C       CALCULATE A NEW SET OF DATA FOR RHO EQUAL TO UNIT DENSITY.
C       ALSO, IF RHO IS 1 AND THE RECORD NUMBER , IS, IS ODD THEN THE
C       PROGRAM WILL CALCULATE D50 VALUES ETC. FOR AERODYNAMIC DIAMETERS
C       BASED ON MERCER'S DEFINITION IN THE NEXT PASS. (IS EVEN)
      IF((IS+1)/2-IS/2)12,12,2020
 2020 RHO1=RHO
      IF(RHO.EQ.1.)NAERO=1
      RHO=1.0
      GO TO 2010
C
C       THIS SECTION FINDS THE MINIMUM (EXCLUDING 0) AND MAXIMUM D50'S
C       (MAX. = MAX. PARTICLE DIAMETER), CUMULATIVE MASS LOADING,
C       GEOMETRIC MEAN DIAMETERS, MASS SIZE DISTRIBUTION VALUES, AND
C       NUMBER SIZE DISTRIBUTION VALUES FOR ALL RUNS. THESE ARE USED TO
C       NAME GRAPHING LIMITS IF PLOT GRIDS ARE DATA REGULATED.
C
   93 DO 3000 N=1,2
      DPMIN(N)=DPCF(N)
      DPMAX(N)=DMAXX(N)
      CUMIN(N)=CUMGF(N)
      CUMAX(N)=CUMG1(N)
      GEMIN(N)=GDMIN(N)
      GEMAX(N)=GDMAX(N)
      DMMIN(N)=DMMN(N)
      DMMAX(N)=DMMX(N)
      DNMIN(N)=DNMN(N)
      DNMAX(N)=DNMX(N)
      LL=N+2
      DO 3000 I=LL,IS,2
      IF(DPCF(I).LT.DPMIN(N))DPMIN(N)=DPCF(I)
      IF(DMAXX(I).GT.DPMAX(N))DPMAX(N)=DMAXX(I)
      IF(CUMGF(I).LT.CUMIN(N))CUMIN(N)=CUMGF(I)
      IF(CUMG1(I).GT.CUMAX(N))CUMAX(N)=CUMG1(I)
      IF(GDMIN(I).LT.GEMIN(N))GEMIN(N)=GDMIN(I)
      IF(GDMAX(I).GT.GEMAX(N))GEMAX(N)=GDMAX(I)
      IF(DMMN(I).LT.DMMIN(N))DMMIN(N)=DMMN(I)
      IF(DMMX(I).GT.DMMAX(N))DMMAX(N)=DMMX(I)
      IF(DNMN(I).LT.DNMIN(N))DNMIN(N)=DNMN(I)
      IF(DNMX(I).GT.DNMAX(N))DNMAX(N)=DNMX(I)
 3000 CONTINUE
C
C        WRITE GENERAL INFORMATION PERTAINING TO ALL RUNS INCLUDING CODE
C        FOR IMPACTOR TYPE, GENERAL IDENTIFICATION LABEL, PHYSICAL
C        DENSITY, AND GRAPHING LIMITS AS FOUND ABOVE.
C
      WRITE(10'101)NRUN,MPACTY,IDALL,RHO1,GEMAX,GEMIN,DMMAX,DMMIN,DNMAX,
     1DNMIN,DPMAX,DPMIN,CUMAX,CUMIN
  600 STOP
   99 FORMAT(2(I2))
 1008 FORMAT(1H1,//,3X,80A1)
 1004 FORMAT(80A1)
  300 FORMAT(F5.2,2F6.1,F4.2,2F5.1,6I1)
  102 FORMAT(5F6,4)
  106 FORMAT(9F6.2)
  310 FORMAT(F7.4)
  111 FORMAT(9F6.2)
  112 FORMAT(F6.2,4I1,F6.2)
  201 FORMAT(1H0,2X,'IMPACTOR FLOWRATE = ',F5.3,' ACFM',15X,'IMPACTOR TE
     1MPERATURE = ',F6.1,' F = ',F5.1,' C',14X,'SAMPLING DURATION = ',F6
     2.2,' MIN',//3X,'IMPACTOR PRESSURE DROP = ',F3.1,' IN. OF HG',7X,'S
     3TACK TEMPERATURE = ',F6.1,' F = ',F5.1,' C',//3X,'ASSUMED PARTICLE
     4 DENSITY = ',F4.2,' GM/CU.CM.',5X,'STACK PRESSURE = ',F5.2' IN. OF
     5 HG',5X,'MAX. PARTICLE DIAMETER = ',F5.1,' MICROMETERS')
  202 FORMAT(1H0,2X,'GAS COMPOSITION (PERCENT)',11X,'CO2 = ',F5.2,10X,'C
     1O = ',F5.2,11X,'N2 = ',F5.2,10X,'O2 = ',F5.2,11X,'H2O = ',F5.2,//3
     2X,'CALC. MASS LOADING =',1PE11.4,' GR/ACF',12X,1PE11.4,' GR/DNCF',
     312X,1PE11.4,' MG/ACM',12X,1PE11.4,' MG/DNCM',//3X,'IMPACTOR STAGE'
     4)
  203 FORMAT('+',43X,'CYC',8X,'S0',8X,'S1',8X,'S2',8X,'S3',8X,'S4',8X,'S
     15',8X,'S6',5X,'FILTER',5X,//3X,'STAGE INDEX NUMBER ',24X,'1',9X,'2
     2',9X,'3',9X,'4',9X,'5',9X,'6',9X,'7',9X,'8',9X,'9',//3X,'D50 (MICR
     3OMETERS)',22X,F5.2,5X,7(F5.2,5X))
  204 FORMAT(1H0,2X,'MG/DNCM/STAGE',26X,9(1PE9.2,1X))
  205 FORMAT('+',54X,'S0',8X,'S1',8X,'S2',8X,'S3',8X,'S4',8X,'S5',8X,'S6
     1',5X,'FILTER',5X,//3X,'STAGE INDEX NUMBER',34X,'1',9X,'2',9X,'3',9
     2X,'4',9X,'5',9X,'6',9X,'7',9X,'8',7X,//3X,'D50 (MICROMETERS)')
  206 FORMAT(1H0,2X,'MG/DNCM/STAGE',36X,8(1PE9.2,1X))
  207 FORMAT(1H0,2X,'MG/DNCM/STAGE',36X,6(1PE9.2,1X),11X,1PE9.2)
  208 FORMAT(1H0,2X,'CUM. PERCENT OF MASS SMALLER THAN D50',10X,7(F6.2,4
     1X))
  209 FORMAT('+',51X,7(F5.2,5X))
  210 FORMAT(1H0,2X,'CUM. (MG/ACM) SMALLER THAN D50')
  211 FORMAT(1H1,'REYNOLDS NUMBERS AND LINEAR VELOCITY AT EACH STAGE')
  212 FORMAT(1H0,5X,'REYN=DC',10X,'REYN=JSPA',10X,'LIN=VEL')
  213 FORMAT(1H0,4X,F8.2,9X,F8.2,10X,F9.2)
  214 FORMAT('+',40X,9(F6.2,4X))
  215 FORMAT(1H0,2X,'CUM. PERCENT OF MASS SMALLER THAN D50',1X,8(F6.2,4X
     1))
  216 FORMAT(1H0,2X,'CUM. (MG/ACM) SMALLER THAN D50')
  217 FORMAT(1H0,2X,'CUM. (MG/DNCM) SMALLER THAN D50')
  218 FORMAT('+',51X,7(1PE9.2,1X))
  219 FORMAT(1H0,2X,'CUM. (GR/ACF) SMALLER THAN D50')
  220 FORMAT(1H0,2X,'MASS (MILLIGRAMS)')
  221 FORMAT('+',41X,1PE9.2)
  222 FORMAT('+',50X,8(F6.2,4X))
  223 FORMAT('+',51X,7(1PE9.2,1X))
  225 FORMAT('+',60X,7(F6.2,4X))
  226 FORMAT('+',61X,6(1PE9.2,1X))
  227 FORMAT('+',121X,F6.2)
  230 FORMAT('+',41X,7(1PE9.2,2X))
  233 FORMAT('+',43X,'CYC',8X,'S0',8X,'S1',8X,'S2',8X,'S3',8X,'S4',8X,'S
     15',15X,'FILTER',5X,//3X,'STAGE INDEX NUMBER',24X,'1',9X,'2',9X,'3'
     2,9X,'4',9X,'5',9X,'6',9X,'7',19X,'8',//3X,'D50 (MICROMETERS)',22X,
     3F5.2,5X,6(F5.2,5X))
  234 FORMAT('+',54X,'S0',8X,'S1',8X,'S2',8X,'S3',8X,'S4',8X,'S5',15X,'F
     1ILTER',5X,//3X,'STAGE INDEX NUMBER',34X,'1',9X,'2',9X,'3',9X,'4',9
     2X,'5',9X,'6',19X,'7',//3X,'D50 (MICROMETERS)')
  235 FORMAT(1H0,2X,'CUM. (GR/DNCF) SMALLER THAN D50')
  236 FORMAT('+',61X,6(F5.2,5X))
  237 FORMAT(1H0,2X,'MG/DNCM/STAGE',46X,5(1PE9.2,1X),11X,1PE9.2)
  238 FORMAT(1H0,2X,'MG/DNCM/STAGE',46X,6(1PE9.2,1X),1PE9.2)
  239 FORMAT('+',64X,'S1',8X,'S2',8X,'S3',8X,'S4',8X,'S5',15X,'FILTER',5
     1X,//3X,'STAGE INDEX NUMBER',44X,'1',9X,'2',9X,'3',9X,'4',9X,'5',19
     2X,'6',//3X,'D50 (MICROMETERS)')
  240 FORMAT('+',64X,'S1',8X,'S2',8X,'S3',8X,'S4',8X,'S5',8X,'S6',5X,'FI
     1LTER',5X,//3X,'STAGE INDEX NUMBER',44X,'1',9X,'2',9X,'3',9X,'4'
     2,9X,'5',9X,'6',9X,'7',//3X,'D50 (MICROMETERS)')
  241 FORMAT(1H0,2X,'CUM. PERCENT OF MASS SMALLER THAN D50',21X,6(F6.2,4
     1X))
  242 FORMAT(1H0,2X,'MG/DSCM/STAGE',26X,7(1PE9.2,1X),11X,1PE9.2)
  243 FORMAT(////1X,'NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG
     1 C AND 760MM HG.')
  244 FORMAT(/1X,'AERODYNAMIC DIAMETERS ARE CALCULATED HERE ',
     1'ACCORDING TO THE TASK GROUP ON LUNG DYNAMICS.')
  245 FORMAT(/1X,'AERODYNAMIC DIAMETERS ARE CALCULATED HERE ',
     1'ACCORDING TO MERCER.')
 3203 FORMAT('+',43X,' S1',8X,'S2',8X,'S3',8X,'S4',8X,'S5',8X,'S6',8X,'S
     17',8X,'S8',5X,'FILTER',5X,//3X,'STAGE INDEX NUMBER',24X,'1',9X,'2'
     2,9X,'3',9X,'4',9X,'5',9X,'6',9X,'7',9X,'8',9X,'9',//3X,'D50 (MICRO
     3METERS)',22X,8(F5.2,5X))
 3113 FORMAT(1H0,2X,'MASS (MILLIGRAMS)',21X,9(F6.2,4X),//3X,'MG/DNCM/STA
     1GE',26X,9(1PE9.2,1X),//3X,'CUM. PERCENT OF MASS SMALLER THAN D50',
     221X,8(0PF6.2,4X))
 3114 FORMAT(1H0,2X,'CUM. (MG/ACM) SMALLER THAN D50',9X,8(1PE9.2,1X),//3
     1X,'CUM. (MG/DNCM) SMALLER THAN D50',8X,8(1PE9.2,1X),//3X,'CUM. (GR
     2/ACF) SMALLER THAN D50',9X,8(1PE9.2,1X),//3X,'CUM. (GR/DNCF) SMALL
     3ER THAN D50',8X,8(1PE9.2,1X))
 6203 FORMAT('+',45X,' S1',8X,'S2',8X,'S3',8X,'S4',8X,'S5',8X,'S6',8X,'S
     17',5X,'FILTER      ',4X,//3X,'STAGE INDEX NUMBER',26X,'1',9X,'2'
     2,9X,'3',9X,'4',9X,'5',9X,'6',9X,'7',9X,'8',9X,' ',//3X,'D50 (MICRO
     3METERS)',24X,7(F5.2,5X))
 6113 FORMAT(1H0,2X,'MASS (MILLIGRAMS)',23X,8(F6.2,4X),//3X,'MG/DSCM/STA
     1GE',28X,8(1PE9.2,1X),//3X,'CUM. PERCENT OF MASS SMALLER THAN D50',
     223X,7(0PF6.2,4X))
 6114 FORMAT(1H0,2X,'CUM. (MG/ACM) SMALLER THAN D50',11X,7(1PE9.2,1X),//
     13X,'CUM. (MG/DNCM) SMALLER THAN D50',10X,7(1PE9.2,1X),//3X,'CUM. (
     2GR/ACF) SMALLER THAN D50',11X,7(1PE9.2,1X),//3X,'CUM. (GR/DNCF) SM
     3ALLER THAN D50',10X,7(1PE9.2,1X))
      END
```
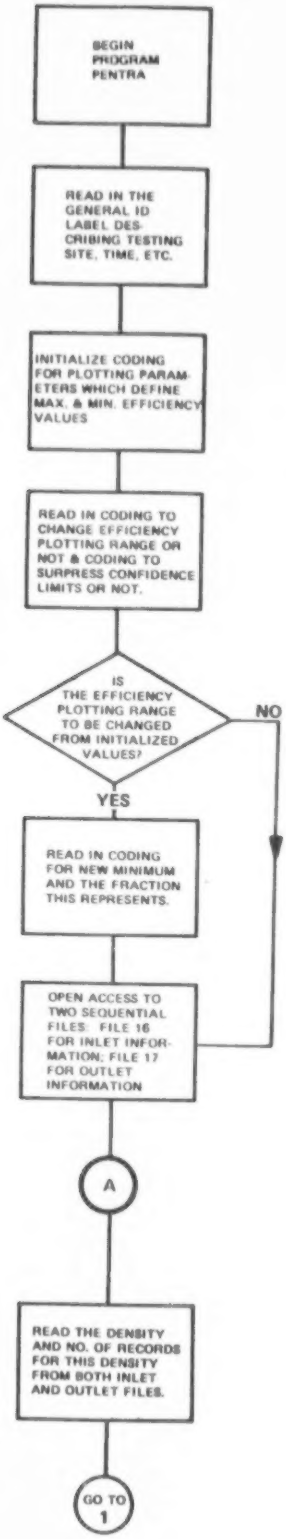
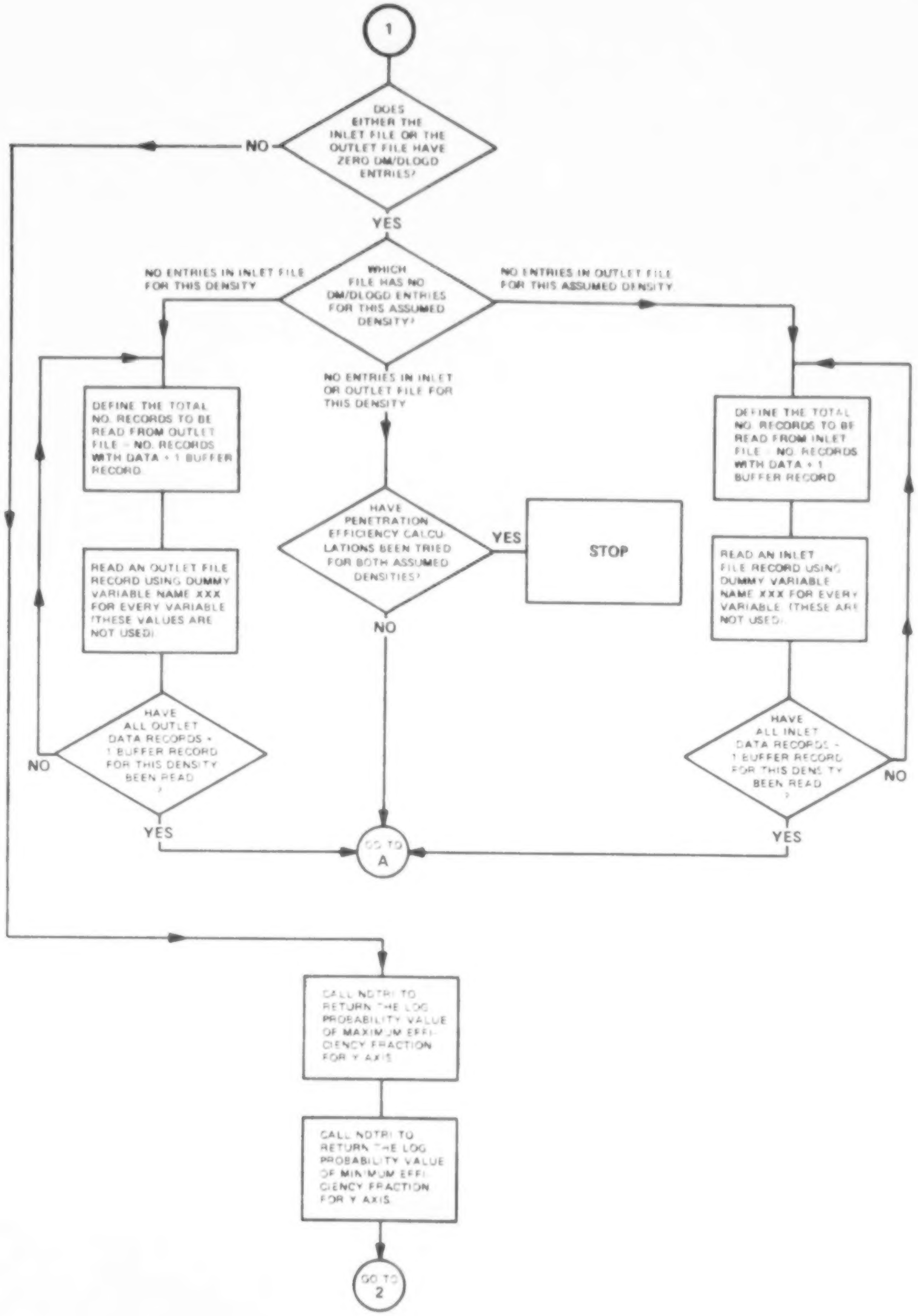
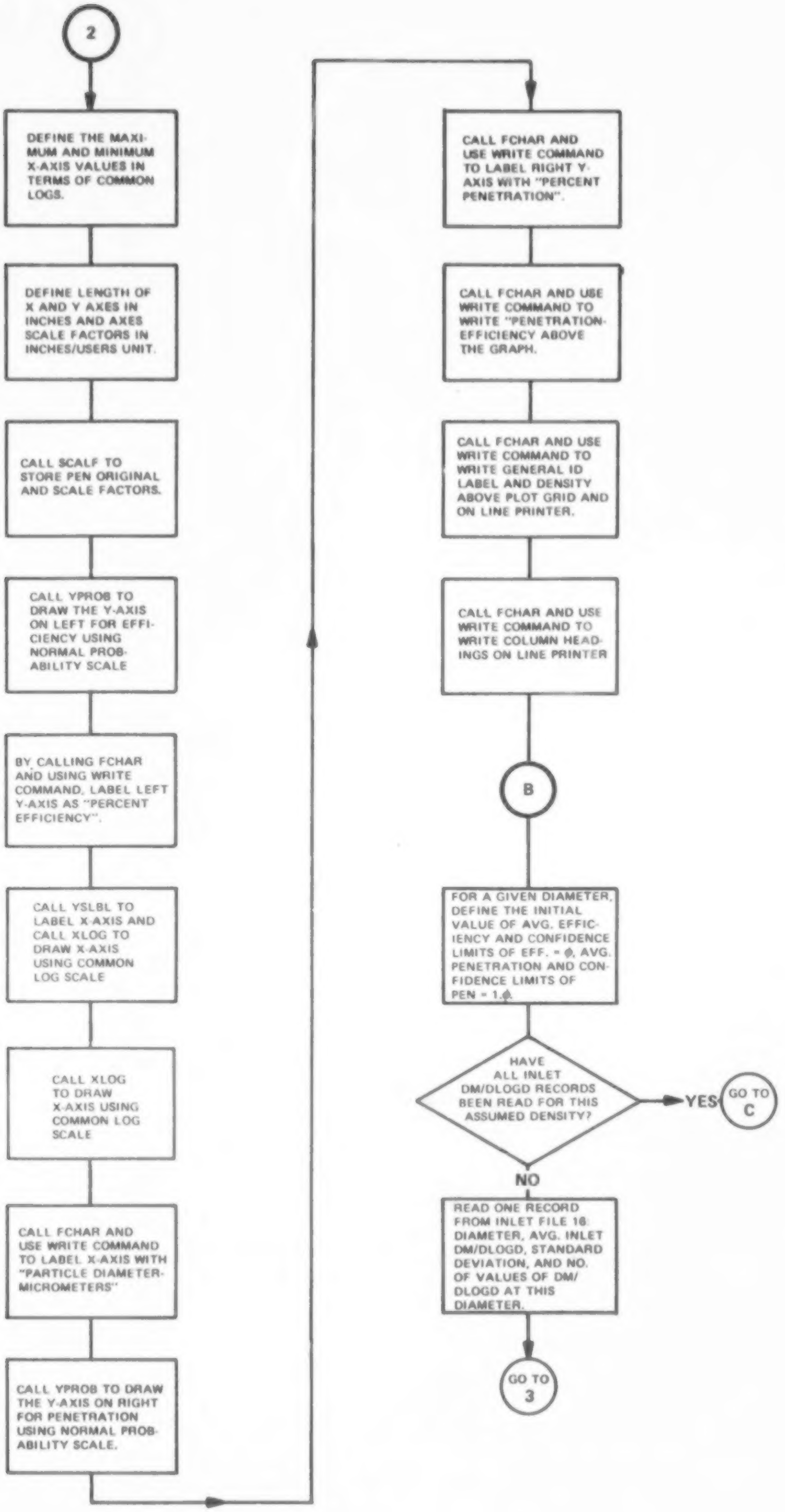
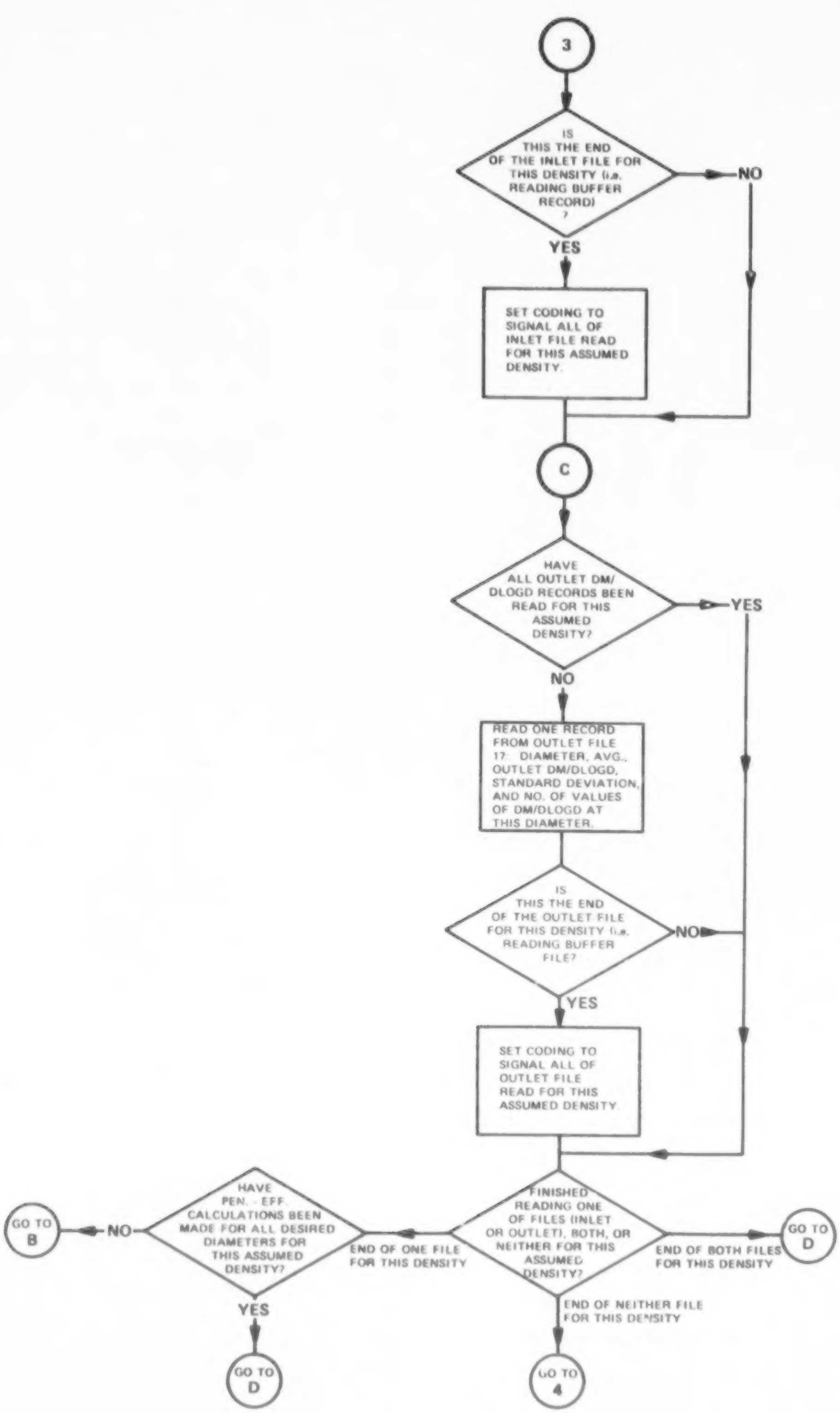
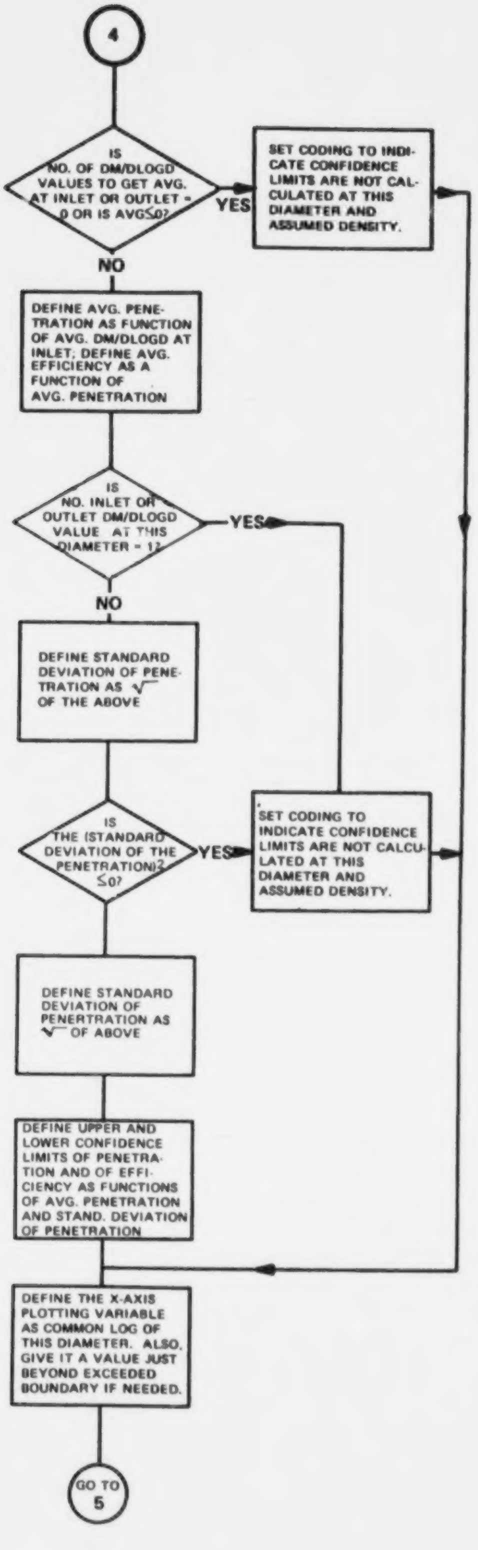
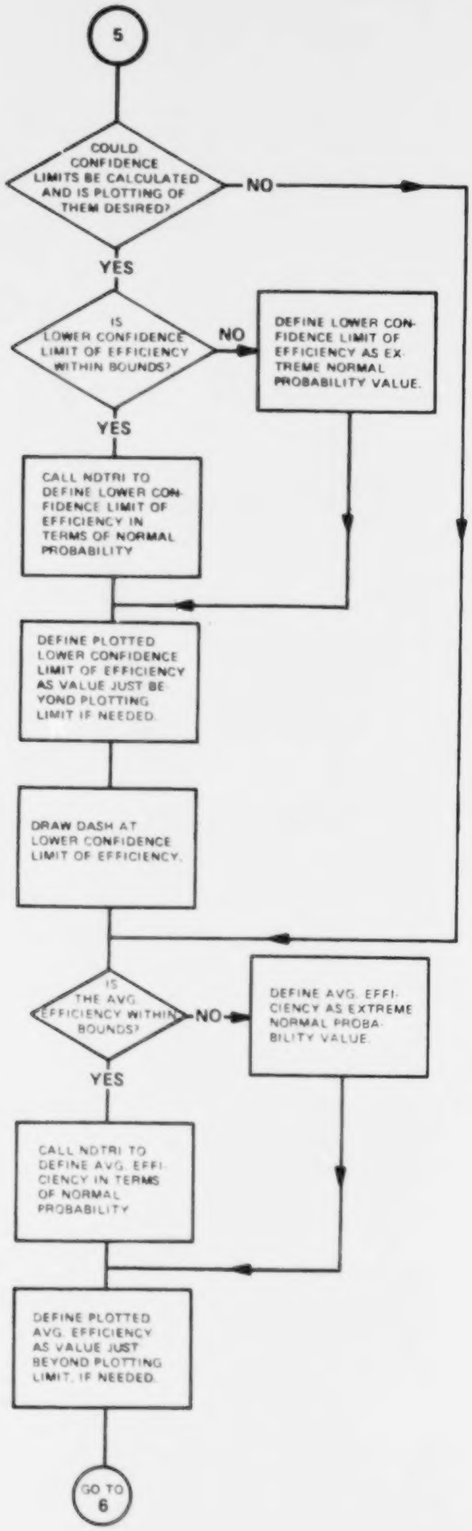


BEGIN PROGRAM PENTRA
READ IN THE GENERAL ID LABEL DESCRIBING TESTING SITE, TIME, ETC.
INITIALIZE CODING FOR PLOTTING PARAMETERS WHICH DEFINE MAX. & MIN. EFFICIENCY VALUES
READ IN CODING TO CHANGE EFFICIENCY PLOTTING RANGE OR NOT & CODING TO SURPRESS CONFIDENCE LIMITS OR NOT.
IS THE EFFICIENCY PLOTTING RANGE TO BE CHANGED FROM INITIALIZED VALUES?
NO
YES
READ IN CODING FOR NEW MINIMUM AND THE FRACTION THIS REPRESENTS.
OPEN ACCESS TO TWO SEQUENTIAL FILES: FILE 16 FOR INLET INFORMATION; FILE 17 FOR OUTLET INFORMATION
A
READ THE DENSITY AND NO. OF RECORDS FOR THIS DENSITY FROM BOTH INLET AND OUTLET FILES.
GO TO 1

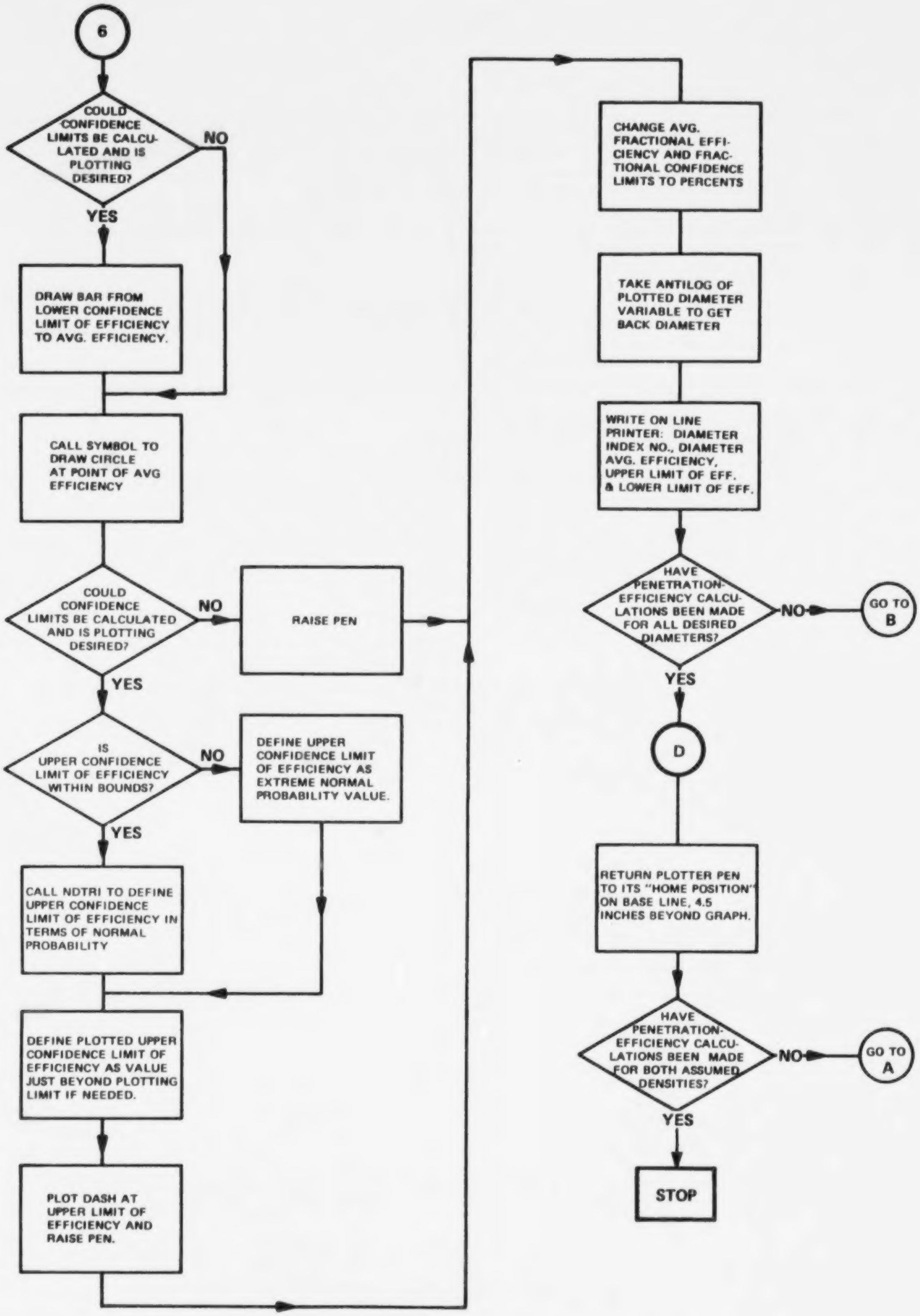

1
DOES EITHER THE INLET FILE OR THE OUTLET FILE HAVE ZERO DM/DLOGD ENTRIES?
NO
YES
WHICH FILE HAS NO DM/DLOGD ENTRIES FOR THIS ASSUMED DENSITY?
NO ENTRIES IN INLET FILE FOR THIS DENSITY
NO ENTRIES IN OUTLET FILE FOR THIS ASSUMED DENSITY
NO ENTRIES IN INLET OR OUTLET FILE FOR THIS DENSITY
DEFINE THE TOTAL NO. RECORDS TO BE READ FROM OUTLET FILE = NO. RECORDS WITH DATA + 1 BUFFER RECORD.
READ AN OUTLET FILE RECORD USING DUMMY VARIABLE NAME XXX FOR EVERY VARIABLE (THESE VALUES ARE NOT USED).
HAVE ALL OUTLET DATA RECORDS + 1 BUFFER RECORD FOR THIS DENSITY BEEN READ ?
NO
YES
HAVE PENETRATION EFFICIENCY CALCULATIONS BEEN TRIED FOR BOTH ASSUMED DENSITIES?
YES
STOP
NO
DEFINE THE TOTAL NO. RECORDS TO BE READ FROM INLET FILE = NO. RECORDS WITH DATA + 1 BUFFER RECORD.
READ AN INLET FILE RECORD USING DUMMY VARIABLE NAME XXX FOR EVERY VARIABLE. (THESE ARE NOT USED).
HAVE ALL INLET DATA RECORDS + 1 BUFFER RECORD FOR THIS DENSITY BEEN READ ?
NO
YES
GO TO A
CALL NDTRI TO RETURN THE LOG PROBABILITY VALUE OF MAXIMUM EFFICIENCY FRACTION FOR Y AXIS.
CALL NDTRI TO RETURN THE LOG PROBABILITY VALUE OF MINIMUM EFFICIENCY FRACTION FOR Y AXIS.
GO TO 2


2
DEFINE THE MAXIMUM AND MINIMUM X-AXIS VALUES IN TERMS OF COMMON LOGS.
DEFINE LENGTH OF X AND Y AXES IN INCHES AND AXES SCALE FACTORS IN INCHES/USERS UNIT.
CALL SCALF TO STORE PEN ORIGINAL AND SCALE FACTORS.
CALL YPROB TO DRAW THE Y-AXIS ON LEFT FOR EFFICIENCY USING NORMAL PROBABILITY SCALE
BY CALLING FCHAR AND USING WRITE COMMAND, LABEL LEFT Y-AXIS AS "PERCENT EFFICIENCY".
CALL YSLBL TO LABEL X-AXIS AND CALL XLOG TO DRAW X-AXIS USING COMMON LOG SCALE
CALL XLOG TO DRAW X-AXIS USING COMMON LOG SCALE
CALL FCHAR AND USE WRITE COMMAND TO LABEL X-AXIS WITH "PARTICLE DIAMETER-MICROMETERS"
CALL YPROB TO DRAW THE Y-AXIS ON RIGHT FOR PENETRATION USING NORMAL PROBABILITY SCALE.
CALL FCHAR AND USE WRITE COMMAND TO LABEL RIGHT Y-AXIS WITH "PERCENT PENETRATION".
CALL FCHAR AND USE WRITE COMMAND TO WRITE "PENETRATION-EFFICIENCY ABOVE THE GRAPH.
CALL FCHAR AND USE WRITE COMMAND TO WRITE GENERAL ID LABEL AND DENSITY ABOVE PLOT GRID AND ON LINE PRINTER.
CALL FCHAR AND USE WRITE COMMAND TO WRITE COLUMN HEADINGS ON LINE PRINTER
B
FOR A GIVEN DIAMETER, DEFINE THE INITIAL VALUE OF AVG. EFFICIENCY AND CONFIDENCE LIMITS OF EFF. = 0, AVG. PENETRATION AND CONFIDENCE LIMITS OF PEN = 1.0.
HAVE ALL INLET DM/DLOGD RECORDS BEEN READ FOR THIS ASSUMED DENSITY?
YES
GO TO C
NO
READ ONE RECORD FROM INLET FILE 16: DIAMETER, AVG. INLET DM/DLOGD, STANDARD DEVIATION, AND NO. OF VALUES OF DM/DLOGD AT THIS DIAMETER.
GO TO 3


3
IS THIS THE END OF THE INLET FILE FOR THIS DENSITY (i.e. READING BUFFER RECORD) ?
NO
YES
SET CODING TO SIGNAL ALL OF INLET FILE READ FOR THIS ASSUMED DENSITY.
C
HAVE ALL OUTLET DM/DLOGD RECORDS BEEN READ FOR THIS ASSUMED DENSITY?
YES
NO
READ ONE RECORD FROM OUTLET FILE 17: DIAMETER, AVG., OUTLET DM/DLOGD, STANDARD DEVIATION, AND NO. OF VALUES OF DM/DLOGD AT THIS DIAMETER.
IS THIS THE END OF THE OUTLET FILE FOR THIS DENSITY (i.e. READING BUFFER FILE?
NO
YES
SET CODING TO SIGNAL ALL OF OUTLET FILE READ FOR THIS ASSUMED DENSITY.
FINISHED READING ONE OF FILES (INLET OR OUTLET), BOTH, OR NEITHER FOR THIS ASSUMED DENSITY?
END OF ONE FILE FOR THIS DENSITY
END OF BOTH FILES FOR THIS DENSITY
GO TO D
END OF NEITHER FILE FOR THIS DENSITY
GO TO 4
HAVE PEN. - EFF. CALCULATIONS BEEN MADE FOR ALL DESIRED DIAMETERS FOR THIS ASSUMED DENSITY?
NO
GO TO B
YES
GO TO D


4
IS NO. OF DM/DLOGD VALUES TO GET AVG. AT INLET OR OUTLET = 0 OR IS AVG≤0?
YES
SET CODING TO INDICATE CONFIDENCE LIMITS ARE NOT CALCULATED AT THIS DIAMETER AND ASSUMED DENSITY.
NO
DEFINE AVG. PENETRATION AS FUNCTION OF AVG. DM/DLOGD AT INLET; DEFINE AVG. EFFICIENCY AS A FUNCTION OF AVG. PENETRATION
IS NO. INLET OR OUTLET DM/DLOGD VALUE AT THIS DIAMETER = 1?
YES
NO
DEFINE STANDARD DEVIATION OF PENETRATION AS √ OF THE ABOVE
IS THE (STANDARD DEVIATION OF THE PENETRATION)² ≤0?
YES
SET CODING TO INDICATE CONFIDENCE LIMITS ARE NOT CALCULATED AT THIS DIAMETER AND ASSUMED DENSITY.
DEFINE STANDARD DEVIATION OF PENERTRATION AS √ OF ABOVE
DEFINE UPPER AND LOWER CONFIDENCE LIMITS OF PENETRATION AND OF EFFICIENCY AS FUNCTIONS OF AVG. PENETRATION AND STAND. DEVIATION OF PENETRATION
DEFINE THE X-AXIS PLOTTING VARIABLE AS COMMON LOG OF THIS DIAMETER. ALSO, GIVE IT A VALUE JUST BEYOND EXCEEDED BOUNDARY IF NEEDED.
GO TO 5


5
COULD CONFIDENCE LIMITS BE CALCULATED AND IS PLOTTING OF THEM DESIRED?
NO
YES
IS LOWER CONFIDENCE LIMIT OF EFFICIENCY WITHIN BOUNDS?
NO
DEFINE LOWER CONFIDENCE LIMIT OF EFFICIENCY AS EXTREME NORMAL PROBABILITY VALUE.
YES
CALL NDTRI TO DEFINE LOWER CONFIDENCE LIMIT OF EFFICIENCY IN TERMS OF NORMAL PROBABILITY
DEFINE PLOTTED LOWER CONFIDENCE LIMIT OF EFFICIENCY AS VALUE JUST BEYOND PLOTTING LIMIT IF NEEDED.
DRAW DASH AT LOWER CONFIDENCE LIMIT OF EFFICIENCY.
IS THE AVG. EFFICIENCY WITHIN BOUNDS?
NO
DEFINE AVG. EFFICIENCY AS EXTREME NORMAL PROBABILITY VALUE.
YES
CALL NDTRI TO DEFINE AVG. EFFICIENCY IN TERMS OF NORMAL PROBABILITY
DEFINE PLOTTED AVG. EFFICIENCY AS VALUE JUST BEYOND PLOTTING LIMIT, IF NEEDED.
GO TO 6


6
COULD CONFIDENCE LIMITS BE CALCULATED AND IS PLOTTING DESIRED?
NO
YES
DRAW BAR FROM LOWER CONFIDENCE LIMIT OF EFFICIENCY TO AVG. EFFICIENCY.
CALL SYMBOL TO DRAW CIRCLE AT POINT OF AVG EFFICIENCY
COULD CONFIDENCE LIMITS BE CALCULATED AND IS PLOTTING DESIRED?
NO
RAISE PEN
YES
IS UPPER CONFIDENCE LIMIT OF EFFICIENCY WITHIN BOUNDS?
NO
DEFINE UPPER CONFIDENCE LIMIT OF EFFICIENCY AS EXTREME NORMAL PROBABILITY VALUE.
YES
CALL NDTRI TO DEFINE UPPER CONFIDENCE LIMIT OF EFFICIENCY IN TERMS OF NORMAL PROBABILITY
DEFINE PLOTTED UPPER CONFIDENCE LIMIT OF EFFICIENCY AS VALUE JUST BEYOND PLOTTING LIMIT IF NEEDED.
PLOT DASH AT UPPER LIMIT OF EFFICIENCY AND RAISE PEN.
CHANGE AVG. FRACTIONAL EFFICIENCY AND FRACTIONAL CONFIDENCE LIMITS TO PERCENTS
TAKE ANTILOG OF PLOTTED DIAMETER VARIABLE TO GET BACK DIAMETER
WRITE ON LINE PRINTER: DIAMETER INDEX NO., DIAMETER AVG. EFFICIENCY, UPPER LIMIT OF EFF. & LOWER LIMIT OF EFF.
HAVE PENETRATION-EFFICIENCY CALCULATIONS BEEN MADE FOR ALL DESIRED DIAMETERS?
NO
GO TO B
YES
D
RETURN PLOTTER PEN TO ITS "HOME POSITION" ON BASE LINE, 4.5 INCHES BEYOND GRAPH.
HAVE PENETRATION-EFFICIENCY CALCULATIONS BEEN MADE FOR BOTH ASSUMED DENSITIES?
NO
GO TO A
YES
STOP

```
C     MAIN PROGRAM PENTRA
C***********************************************************************
C*    PENTRA COMPARES INLET IMPACTOR DATA TO OUTLET IMPACTOR DATA TO FIND
C*    PERCENT EFFICIENCY. IN ORDER TO EXECUTE THIS PROGRAM THE IMPACTOR
C*    PROGRAM MPPROG MUST HAVE BEEN RUN IN ADDITION TO PROGRAMS
C*    SPLIN1 AND STATIS. SPLIN1 USES DATA RECORDED
C*    DURING THE IMPACTOR PROGRAM EXECUTION IN ORDER TO MAKE FITS TO DATA.
C*    STATIS USES THESE FITTED EQUATIONS TO FIND AVERAGE DM/DLOGD VALUES
C*    AND STANDARD DEVIATION AT SPECIFIED PARTICLE
C*    SIZES, AND STORES THESE VALUES
C*    IN THE APPROPRIATE IMPACTOR FILE. THEN PROGRAM PENTRA MAKES A 'PARALLE
C*    READING OF BOTH INLET AND OUTLET SEQUENTIAL FILES. CALCULATIONS
C*    YIELD PRINT OUT AND PLOT OF THE CONTROL DEVICE'S PERCENT EFFICIENCY
C*    AT SPECIFIED PARTICLE SIZES.
C*         USE THIS PROGRAM FOR 50 % CONFIDENCE LIMITS
C***********************************************************************
C
      DIMENSION FILNM1(2),FILNM2(2)
      DIMENSION IPROG(2),IDGEN(80),RBUF(8)
      EQUIVALENCE (RBUF(1),RSLOT),(RBUF(2),DPLOT)
      EQUIVALENCE (RBUF(3),AVEFF),(RBUF(4),CLUE),(RBUF(5),CLLE)
      EQUIVALENCE (RBUF(6),AVPEN),(RBUF(7),CLUP),(RBUF(8),CLLP)
      DATA IBLAK/' '/
      DATA FILNM1/'JWJ00','1BIN'/
      DATA FILNM2/'JWJ00','2BIN'/
      DATA DAST/'*****'/
C
C     READ THE GENERAL IDENTIFICATION LABEL
C
      READ(2,12)IDGEN
C
C     IMIN AND IMAX ARE THE CODE NUMBERS WHICH DETERMINE THE RANGE OF THE
C     NORMAL PROBABILITY SCALE TO BE PRINTED AS Y - AXIS FOR PLOT.
C     IMIN = 16 YIELDS MINIMUM 80 PERCENT. IMAX 25 YIELDS MAXIMUM 99.99
C     PERCENT. FOR OTHER CODE VALUES AND RESULTING PLOT RANGE, SEE
C     SUBROUTINE YPROB. YMINFR (= .800 FOR 80 PERCENT) IS MINIMUM
C     FRACTIONAL EFFICIENCY ON PLOT.
C
      IMIN=16
      IMAX=25
      YMINFR=.800
C
C     ICHRAN = 0 -- YMIN=16,YMINFR=.800. ICHRAN NOT = 0, READ IN THESE.
C     NSPCON = 0 -- PLOT CONFIDENCE LIMITS IF POSSIBLE.
C     NSPCON NOT = 0 -- SUPPRESS.
C
      READ(2,501)ICHRAN,NSPCON
      IF(ICHRAN)18,19,18
   18 READ(2,500)IMIN
      READ(2,510)YMINFR
C
C     FILE 16 CONTAINS INLET INFORMATION.
C     FILE 17 CONTAINS OUTLET INFORMATION.
C
   19 CALL SEEK(16,FILNM1)
      CALL SEEK(17,FILNM2)
C
C     WHEN MDEX = 1  SEARCH FILES FOR DATA WHERE RHO = PHYSICAL DENSITY.
C     WHEN MDEX = 2  SEARCH FILES FOR DATA WHERE RHO = 1.0 GM/CC.
```

```
C
      DO 200 MDEX=1,2
C
C     IF ONE FILE DOES NOT HAVE COMPLETE RECORDS FOR GIVEN DENSITY
C     (INDICATED BY LAS1 OR LAS2 = 0), AND THE OTHER FILE DOES,
C     THIS LATTER FILE MUST BE READ IN ORDER TO ALWAYS READ 'PARALLEL'
C     RECORDS FROM EACH FILE. I.E. THE 2 RECORDS READ, 1 FROM EACH FILE,
C     MUST REPRESENT DATA AT THE SAME DIAMETER. THIS ORDER IS IMPERATIVE
C     SINCE THE FILES ARE SEQUENTIAL (AS OPPOSED TO RANDOM FILES).
C     LAS1 AND LAS2 ARE THE NUMBER OF RECORDS TO BE READ.
C
      READ(16)RHO,LAS1
      READ(17)RHO,LAS2
C
C     THE 'COMPLETE' FILE IS READ,ALTHOUGH ARGUMENTS ARE ONLY DUMMY
C     ARGUMENTS AND CAN NOT BE USED TO FIND PERCENT EFFICIENCY.
C
      IF(LAS1*LAS2)126,126,131
  126 IF(LAS1-LAS2)127,200,129
  127 LEND=LAS2+1
      DO 128 I=1,LEND
  128 READ(17)XXX,XXX,XXX,IXX
      GO TO 200
C
  129 LEND=LAS1+1
      DO 130 I=1,LEND
  130 READ(16)XXX,XXX,XXX,IXX
      GO TO 200
C
C     NDTRI DETERMINES THE EXTREME Y - AXIS VALUES, YMAX AND YMIN, IN
C     TERMS OF THE NORMAL PROBABILITY SCALE.
C
  131 CALL NDTRI(0.9999,YMAX,D,IE)
      CALL NDTRI(YMINER,YMIN,D,IE)
C
C     THESE ARE THE EXTREME X - AXIS VALUES, XMAX AND XMIN, IN TERMS OF
C     THE LOG10 SCALE.
C
      XMAX=ALOG10(100.0)
      XMIN=ALOG10(.1)
C
C     THESE ARE THE LENGTHS OF THE X AND Y AXES IN INCHES.
C
      XINCH=4.5
      YINCH=6.5
C
C     XS AND YS ARE THE SCALE FACTORS (INCHES/USER'S UNIT).
C
      XS=XINCH/(XMAX-XMIN)
      YS=YINCH/(YMAX-YMIN)
C
C     COORDINATES XMIN AND Y0 DEFINE THE LOCATION OF THE PEN IN TERMS OF
C     THE USER'S UNITS WHEN THIS PROGRAM BEGINS. (XMIN,YMIN) ARE THE
C     COORDINATES OF THE USER'S ORIGIN.
C     SUBROUTINE SCALF STORES ITS ARGUMENTS FOR USE BY OTHER PLOTTING
C     SUBROUTINES.
C
      Y0=YMIN-2./YS
      CALL SCALF(XS,YS,XMIN,Y0)
C
```

```
C     THIS SECTION DRAWS THE Y - AXIS ON THE LEFT AND LABELS IT AS
C     'PERCENT EFFICIENCY'.
C
      CALL YPROB(XS,YS,XMIN,0,IMIN,IMAX)
      XCS=.15
      YCS=.15
      X=XMIN-1.0/XS
      Y=((YMAX-YMIN)/2.0)+YMIN-((9.0*YCS)/YS)
      PI=3.1415
      CALL FCHAR(X,Y,XCS,YCS,PI/2.)
      WRITE(7,3)
C
C     THIS SECTION DRAWS THE X - AXIS AND LABELS IT 'PARTICLE
C     DIAMETER (MICROMETERS)'.
C
      IXRAN=XMAX-XMIN
      CALL XSLBL(XS,YS,XMIN,YMIN,IXRAN,XMIN)
      CALL XLOG(XS,YS,XMAX,YMIN,-1,IXRAN)
      X=((XMAX-XMIN)/2.0)+XMIN-((16.0*XCS)/XS)
      Y=YMIN-(.7/YS)
      CALL FCHAR(X,Y,XCS,YCS,0.)
      WRITE(7,2)
C
C     THIS SECTION DRAWS THE Y - AXIS ON THE RIGHT AND LABELS IT AS
C     'PERCENT PENETRATION'.
C
      CALL YPROB(XS,YS,XMAX,1,IMIN,IMAX)
      X=XMAX+1.0/XS
      Y=((YMAX-YMIN)/2.0)+YMIN-((9.0*YCS)/YS)
      CALL FCHAR(X,Y,XCS,YCS,PI/2.)
      WRITE(7,1)
C
C     THIS SECTION WRITES 'PENETRATION-EFFICIENCY' ABOVE GRAPH.
C
      XCS=.12
      YCS=.12
      X=((XMAX-XMIN)/2.)+XMIN-((11.*XCS)/XS)
      Y=YMAX+.75/YS
      CALL FCHAR(X,Y,XCS,YCS,0.)
      WRITE(7,4)
C
C     THIS SECTION WRITES THE GENERAL IDENTIFICATION LABEL IDGEN AND DENSITY
C     RHO ABOVE PLOT AND AT TOP OF PAGE ON LINE PRINTER.
C
      X=XMIN
      Y=YMAX+.5/YS
      XCS=.056
      YCS=.100
      DO 30 I=1,79
      J=80-I
      IF(IDGEN(J).NE.IBLAK)GO TO 40
   30 CONTINUE
      J=1
   40 CALL FCHAR(X,Y,XCS,YCS,0.)
      WRITE(7,5)(IDGEN(I),I=1,J)
      X=XMIN
      Y=YMAX+.25/YS
      CALL FCHAR(X,Y,XCS,YCS,0.)
      WRITE(7,6)RHO
      WRITE(3,7)(IDGEN(I),I=1,J)
      WRITE(3,17)RHO
C
C     THIS STATEMENT WRITES COLUMN HEADINGS - 'INTERVAL','DIAMETER',
C     'AVERAGE EFFICIENCY','UPPER CONFIDENCE LIMIT OF EFFICIENCY' AND
C     'LOWER CONFIDENCE LIMIT OF EFFICIENCY'.
C
      WRITE(3,8)
      ISIG=0
      KSIG=0
C
C     THIS LOOP READS INLET AND OUTLET FILES . CALCULATES,PLOTS, AND GIVES
C     PRINT OUT FOR PERCENT EFFICIENCY.
C
      DO 100 NSLOT=1,100
      RSLOT=NSLOT
      AVEFF=0.0
      CLUE=0.0
      CLLE=0.0
      AVPEN=1.0
      CLUP=1.0
      CLLP=1.0
      NCON=0
C
C     RECORDS ARE READ FROM IFILE UNTIL END OF RECORDS FOR THIS DENSITY
C     IS SIGNALED BY 5 ASTERISKS (DAST). THEN ISIG SET = 1 UNTIL KFILE
C     READINGS ARE COMPLETED. THIS IS DONE LIKEWISE FOR KFILE USING
C     KSIG = 1 IF IFILE SHOULD HAVE MORE RECORDS THAN KFILE.
C
      IF(ISIG.EQ.1)GO TO 45
      READ(16)DPLOT,AVIN,SIGIN,NIN
      IF(DPLOT.EQ.DAST)ISIG=1
   45 IF(KSIG.EQ.1)GO TO 47
      READ(17)DPLOT,AVOUT,SIGOUT,NOUT
      IF(DPLOT.EQ.DAST)KSIG=1
C
C     IF END OF RECORDS FOR THIS DENSITY HAS BEEN REACHED IN BOTH FILES,
C     ISIG = 1 AND KSIG = 1.
C
C     IF END OF RECORDS FOR THIS DENSITY HAS BEEN REACHED IN ONLY ONE
C     OF THE FILES, LOOP CONTINUES TO RETURN AND READ THE LONGER FILE.
C
   47 IF(ISIG+KSIG-1)210,100,150
  210 IF(AVIN*NIN*NOUT)215,215,220
  215 NCON=1
      GO TO 50
  220 AVPEN=AVOUT/AVIN
      AVEFF=1.0-AVPEN
      IF(NIN.EQ.1.OR.NOUT.EQ.1) GO TO 221
      ROUT=NOUT
      RIN=NIN
      TOUT=(0.674+(0.32*((ROUT-1.)**(-1.072))))/SQRT(ROUT)
      TIN=(0.674+(0.32*((RIN-1.)**(-1.072))))/SQRT(RIN)
      SIGIO=AVPEN*AVPEN*((TOUT*SIGOUT/AVOUT)**2/ROUT+(TIN*SIGIN/AVIN)**2
     1/RIN)
      IF(SIGIO)221,221,225
  221 NCON=1
      GO TO 50
  225 SIGIO=SQRT(SIGIO)
      CLUP=AVPEN+SIGIO
      CLLP= AVPEN-SIGIO
   48 CLUE=1.0-CLLP
      CLLE=1.0-CLUP
C
C     THIS SECTION PLOTS THE AVERAGE PERCENT EFFICIENCY WITH UPPER AND
C     LOWER CONFIDENCE LIMITS VS. PARTICLE DIAMETER.
C
   50 DPLOT=ALOG10(DPLOT)
C
C     FUNCTIONS XVAL AND YVAL CHECK FOR VALUES OUTSIDE PLOTTING GRID.
C     A VALUE .25 INCHES OUTSIDE OF THE GRID IS GIVEN TO ANY SUCH POINTS.
C     OTHERWISE THE VALUE IS NOT CHANGED.
C
      XN=XVAL(DPLOT,XMAX,XMIN,XS)
C
C     IF LOWER CONFIDENCE LIMIT CLLE IS TO BE DRAWN, FIND ITS VALUE
C     IN TERMS OF NORMAL PROBABILITY SCALE.
C
      IF(NCON.NE.0.OR.NSPCON.NE.0) GO TO 327
C
C
C     IF CLLE < .0001, SET YV = ARBITRARY NUMBER < YMIN.
C
      IF(CLLE-.0001)305,310,310
  305 YV=-4.0
      GO TO 325
C
C     IF CLLE IS > .9999, SET YV = ARBITRARY NUMBER > YMAX.
C
  310 IF(.9999-CLLE)315,320,320
  315 YV=4.0
      GO TO 325
C
C     SUBROUTINE NDTRI(P,S,D,IE) FINDS THE VALUE OF P IN TERMS OF
C     NORMAL PROBABILITY SCALE FOR .0001 < P < .9999. THIS RETURNED
C     VALUE IS S.
C
  320 CALL NDTRI(CLLE,YV,D,IE)
C
C     CHECK TO SEE THAT LOWER CONFIDENCE LIMIT IS WITHIN PLOTTING
C     LIMITS. DRAW HORIZONTAL LOWER CONFIDENCE LIMIT TICK.
C
  325 YN=YVAL(YV,YMAX,YMIN,YS)
      XN=XN-.03/XS
      CALL FPLOT(-2,XN,YN)
      XN=XN+.06/XS
      CALL FPLOT(0,XN,YN)
      XN=XN-.03/XS
      CALL FPLOT(0,XN,YN)
C
C     FIND VALUE OF AVEFF IN TERMS OF NORMAL PROBABILITY SCALE AS
C     FOR CLLE ABOVE.
C
  327 IF(AVEFF-.0001)330,335,335
  330 YV=-4.0
      GO TO 350
  335 IF(.9999-AVEFF)340,345,345
  340 YV=4.0
      GO TO 350
  345 CALL NDTRI(AVEFF,YV,D,IE)
C
```

```
C     CHECK TO SEE THAT AVERAGE IS WITHIN PLOTTING LIMITS, DRAW
C     VERTICAL BAR FROM LOWER CONFIDENCE LIMIT TO AVERAGE.
C
  350 YN=YVAL(YV,YMAX,YMIN,YS)
      CALL FPLOT(0,XN,YN)
      IF(NCON.NE.0.OR.NSPCON.NE.0) CALL FPLOT(2,XN,YN)
C
C     SUBROUTINE SYMBOL(I,S) DRAWS A SYMBOL DETERMINED BY I (HERE I = 9,
C     THEREFORE DRAWS SOLID CIRCLE) INSIDE A SQUARE OF DIMENSION S.
C
      CALL SYMBOL(9,.04)
C
C     IF UPPER CONFIDENCE LIMIT CLUE IS TO BE DRAWN, FIND ITS VALUE
C     IN TERMS OF NORMAL PROBABILITY SCALE.
C
      IF(NCON.EQ.0.AND.NSPCON.EQ.0)GO TO 354
  353 CALL FPLOT(1,XN,YN)
      GO TO 55
  354 IF(CLUE-.0001)355,360,360
  355 YV=-4.0
      GO TO 375
  360 IF(.9999-CLUE)365,370,370
  365 YV=4.0
      GO TO 375
  370 CALL NDTRI(CLUE,YV,D,IE)
C
C     CHECK TO SEE THAT UPPER CONFIDENCE LIMIT IS WITHIN PLOTTING
C     LIMITS, DRAW VERTICAL BAR FROM AVERAGE TO UPPER CONFIDENCE LIMIT
C     AND DRAW HORIZONTAL TICK.
C
  375 YN=YVAL(YV,YMAX,YMIN,YS)
      CALL FPLOT(0,XN,YN)
      XN=XN-.03/XS
      CALL FPLOT(0,XN,YN)
      XN=XN+.06/XS
      CALL FPLOT(-1,XN,YN)
C
C     THIS LOOP CHANGES FRACTIONAL EFFICIENCY TO PERCENT EFFICIENCY FOR
C     PRINTING.
C
   55 DO 60 I=3,5
      RBUF(I)=RBUF(I)*100.
      IF(RBUF(I).GE.100.0)RBUF(I)=100.0
      IF(RBUF(I).LE.0.0)RBUF(I)=0.0
   60 CONTINUE
C
C     CHANGE FROM LOG10 DIAMETER TO DIAMETER FOR PRINTING.
C
      DPLOT=10.0**DPLOT
C
C     WRITE DIAMETER INDEX NUMBER, DIAMETER, EFFICIENCY, UPPER
C     LIMIT OF EFFICIENCY, AND LOWER LIMIT OF EFFICIENCY.
C
   70 WRITE(3,11)(RBUF(I),I=1,5)
  100 CONTINUE
C
C     RETURN PLOTTER PEN TO BASE LINE 3 INCHES BEYOND GRID, THEN READY
C     FOR NEXT PLOT.
C
  150 XN=XMAX+4.5/XS
```

```
      YN=Y0
      CALL FPLOT(0,XN,YN)
  200 CONTINUF
    1 FORMAT(1X,'PERCENT PENETRATION')
    2 FORMAT(1X,'PARTICLE DIAMETER (MICROMETERS)')
    3 FORMAT(1X,'PERCENT EFFICIENCY')
    4 FORMAT(1X,'PENETRATION-EFFICIENCY')
    5 FORMAT(1X,80A1)
    6 FORMAT(1X,'RHO= ',F4.2,' GM/CC')
    7 FORMAT(1H1,1X,80A1)
   17 FORMAT(1X,'RHO= ',F4.2,' GM/CC')
    8 FORMAT(38X,'UPPER CONFIDENCE',3X,'LOWER CONFIDENCE'/,
     127X,'AVERAGE',7X,'LIMIT OF',11X,'LIMIT OF'/,
     23X,'INTERVAL',3X,'DIAMETER',3X,'EFFICIENCY',5X,'EFFICIENCY',
     38X,'EFFICIENCY'/)
   11 FORMAT(6X,F3.0,3X,F8.4,5X,F8.4,7X,F8.4,11X,F8.4)
   12 FORMAT(80A1)
  500 FORMAT(2I2)
  501 FORMAT(2I1)
  510 FORMAT(F5.4)
      STOP
      END
```

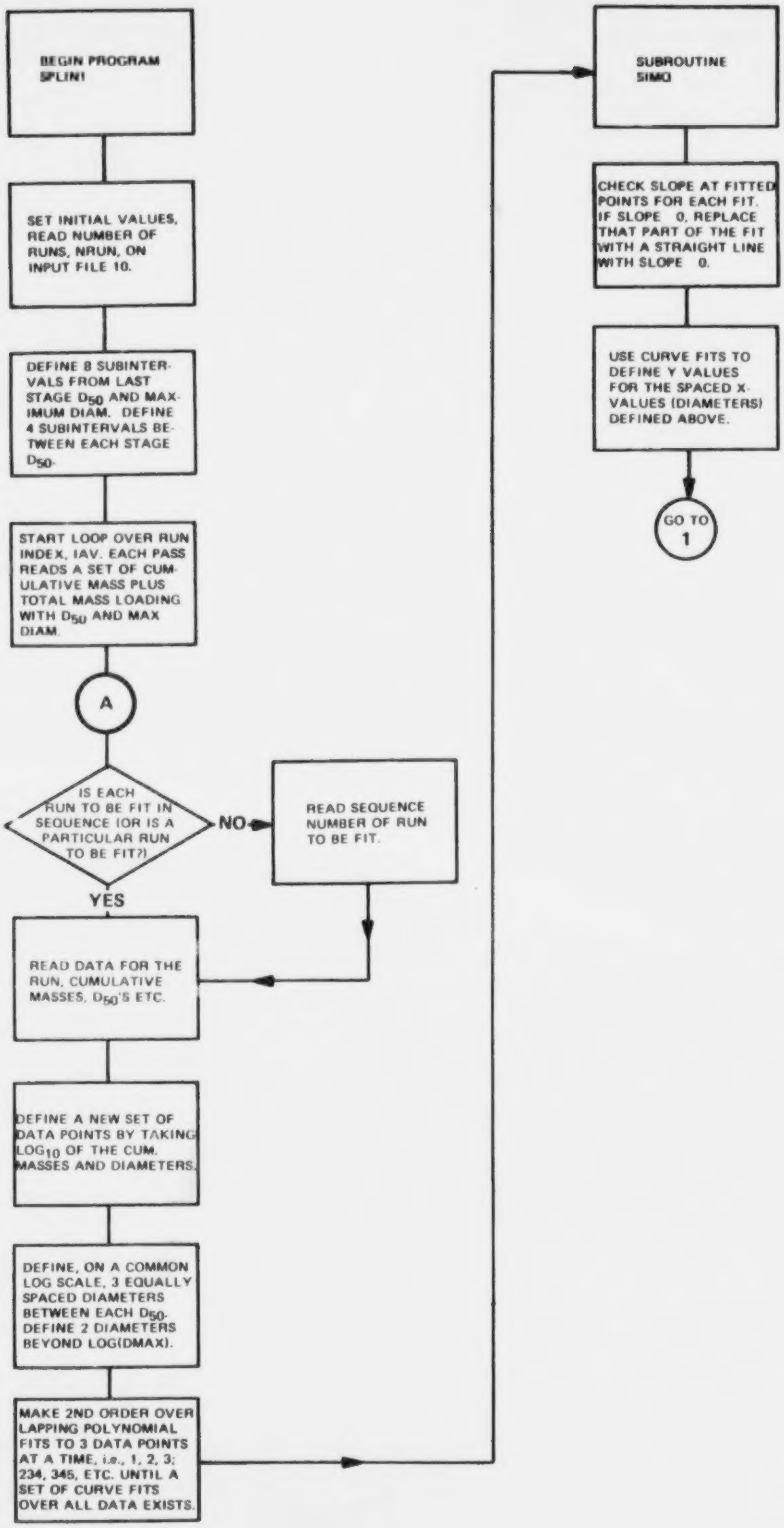
```
C     MAIN PROGRAM PENLOG
C***********************************************************************
C*    PENLOG COMPARES INLET IMPACTOR DATA TO OUTLET IMPACTOR DATA TO FIND
C*    PERCENT EFFICIENCY. IN ORDER TO EXECUTE THIS PROGRAM THE IMPACTOR
C*    PROGRAM MPPROG MUST HAVE BEEN RUN IN ADDITION TO PROGRAMS
C*    SPLIN1 AND STATIS, SPLIN1 USES DATA RECORDED
C*    DURING THE IMPACTOR PROGRAM EXECUTION IN ORDER TO MAKE FITS TO DATA.
C*    STATIS USES THESE FITTED EQUATIONS TO FIND AVERAGE DM/DLOGD VALUES
C*    AND STANDARD DEVIATION AT SPECIFIED PARTICLE
C*    SIZES, AND STORES THESE VALUES
C*    IN THE APPROPRIATE IMPACTOR FILE. THEN PROGRAM PENLOG MAKES A 'PARALLE
C*    READING OF BOTH INLET AND OUTLET SEQUENTIAL FILES, CALCULATIONS
C*    YIELD PRINT OUT AND PLOT OF THE CONTROL DEVICE'S PERCENT EFFICIENCY
C*    AT SPECIFIED PARTICLE SIZES.
C*        USE THIS PROGRAM FOR 50 % CONFIDENCE LIMITS
C***********************************************************************
C
      DIMENSION FILNM1(2),FILNM2(2)
      DIMENSION IPROG(2),IDGEN(80),RBUF(8)
      DIMENSION TV(10)
      EQUIVALENCE (RBUF(1),RSLOT),(RBUF(2),DPLOT)
      EQUIVALENCE (RBUF(3),AVEFF),(RBUF(4),CLUE),(RBUF(5),CLLE)
      EQUIVALENCE (RBUF(6),AVPEN),(RBUF(7),CLUP),(RBUF(8),CLLP)
      DATA TV/99.99,99.98,99.95,99.9,99.8,99.5,99.0,98.0,95.0,90.0/
      DATA IBLAK/' '/
      DATA FILNM1/'JWJ00','1BIN'/
      DATA FILNM2/'JWJ00','2BIN'/
      DATA DAST/'*****'/
C
C     READ THE GENERAL IDENTIFICATION LABEL
C
      READ(2,12)IDGEN
C
C     NSPCON = 0 -- PLOT CONFIDENCE LIMITS IF POSSIBLE.
C     NSPCON NOT = 0 -- SUPPRESS.
C
      READ(2,501) NSPCON
C
C     FILE 16 CONTAINS INLET INFORMATION.
C     FILE 17 CONTAINS OUTLET INFORMATION.
C
      CALL SEEK (16,FILNM1)
      CALL SEEK(17,FILNM2)
C
C     WHEN MDEX = 1  SEARCH FILES FOR DATA WHERE RHO = PHYSICAL DENSITY.
C     WHEN MDEX = 2  SEARCH FILES FOR DATA WHERE RHO = 1.0 GM/CC.
C
      DO 200 MDEX=1,2
C
C     IF ONE FILE DOES NOT HAVE COMPLETE RECORDS FOR GIVEN DENSITY
C     (INDICATED BY LAS1 OR LAS2 = 0), AND THE OTHER FILE DOES,
C     THIS LATTER FILE MUST BE READ IN ORDER TO ALWAYS READ 'PARALLEL'
C     RECORDS FROM EACH FILE. I.E. THE 2 RECORDS READ, 1 FROM EACH FILE,
C     MUST REPRESENT DATA AT THE SAME DIAMETER. THIS ORDER IS IMPERATIVE
C     SINCE THE FILES ARE SEQUENTIAL (AS OPPOSED TO RANDOM FILES).
C     LAS1 AND LAS2 ARE THE NUMBER OF RECORDS TO BE READ.
C
      READ(16)RHO,LAS1
      READ(17)RHO,LAS2
```

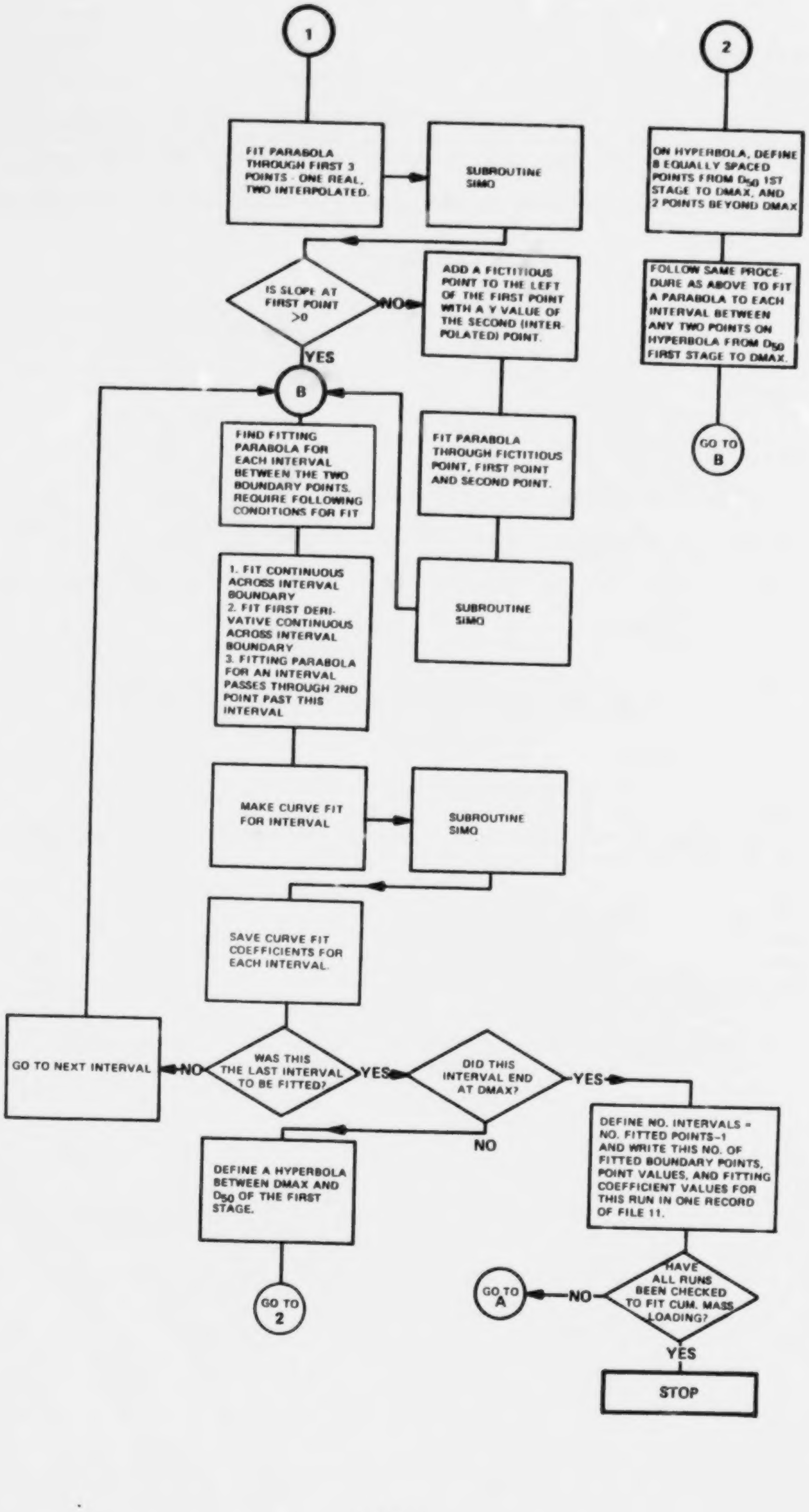
```
C
C     THE 'COMPLETE' FILE IS READ,ALTHOUGH ARGUMENTS ARE ONLY DUMMY
C     ARGUMENTS AND CAN NOT BE USED TO FIND PERCENT EFFICIENCY.
C
      IF(LAS1*LAS2)126,126,131
  126 IF(LAS1-LAS2)127,200,129
  127 LEND=LAS2+1
      DO 128 I=1,LEND
  128 READ(17)XXX,XXX,XXX,IXX
      GO TO 200
C
  129 LEND=LAS1+1
      DO 130 I=1,LEND
  130 READ(16)XXX,XXX,XXX,IXX
      GO TO 200
C
C     THESE ARE THE EXTREME Y - AXIS VALUES, YMAX AND YMIN, IN TERMS OF
C     THE LOG10 SCALE.
C
  131 YMAX=ALOG10(10.0)
      YMIN=ALOG10(.01)
C
C     THESE ARE THE EXTREME X - AXIS VALUES, XMAX AND XMIN, IN TERMS OF
C     THE LOG10 SCALE.
C
      XMAX=ALOG10(100.0)
      XMIN=ALOG10(.1)
C
C     THESE ARE THE LENGTHS OF THE X AND Y AXES IN INCHES.
C
      XINCH=4.5
      YINCH=6.5
C
C     XS AND YS ARE THE SCALE FACTORS (INCHES/USER'S UNIT).
C
      XS=XINCH/(XMAX-XMIN)
      YS=YINCH/(YMAX-YMIN)
C
C     COORDINATES XMIN AND YO DEFINE THE LOCATION OF THE PEN IN TERMS OF
C     THE USER'S UNITS WHEN THIS PROGRAM BEGINS, (XMIN,YMIN) ARE THE
C     COORDINATES OF THE USER'S ORIGIN.
C     SUBROUTINE SCALF STORES ITS ARGUMENTS FOR USE BY OTHER PLOTTING
C     SUBROUTINES.
C
      YO=YMIN-2./YS
      CALL SCALF(XS,YS,XMIN,YO)
C
C     THIS SECTION DRAWS THE Y - AXIS ON THE RIGHT AND LABELS IT AS
C     'PERCENT PENETRATION'.
C
      CALL YLOG(XS,YS,XMIN,YMAX,-1,3)
      CALL LGLBL(XS,YS,XMIN,YMIN,3,-2,.1)
      XCS=.15
      YCS=.15
      X=XMIN-1.0/XS
      Y=((YMAX-YMIN)/2.0)+YMIN-((9.0*YCS)/YS)
      PI=3.1415
      CALL FCHAR(X,Y,XCS,YCS,PI/2.)
      WRITE(7,1)
C
```

```
C     THIS SECTION DRAWS THE X - AXIS AND LABELS IT 'PARTICLE
C     DIAMETER (MICROMETERS)'.
C
      IXRAN=XMAX-XMIN
      CALL XSLBL(XS,YS,XMIN,YMIN,IXRAN,XMIN)
      CALL XLOG(XS,YS,XMAX,YMIN,-1,IXRAN)
      X=((XMAX-XMIN)/2.0)+XMIN-((16.0*XCS)/XS)
      Y=YMIN-(.7/YS)
      CALL FCHAR(X,Y,XCS,YCS,0.)
      WRITE(7,2)
C
C     THIS SECTION DRAWS THE Y - AXIS ON THE LEFT AND LABELS IT AS
C     'PERCENT EFFICIENCY'.
C
      CALL YLOG(XS,YS,XMAX,YMIN,1,3)
      XCS=0.15
      YCS=0.15
      J=0
      DO 27 I=1,10,3
      J=J+1
      X=XMAX+XCS/XS
      Y=YMIN+J-1-.075/YS
      CALL FCHAR(X,Y,XCS,YCS,0.)
      IF(I-3)25,25,20
   20 WRITE(7,21)TV(I)
   21 FORMAT(1X,F4.1)
      GO TO 27
   25 WRITE(7,26)TV(I)
   26 FORMAT(1X,F5.2)
   27 CONTINUE
      X=XMAX+1.0/XS
      Y=((YMAX-YMIN)/2.0)+YMIN-((9.0*YCS)/YS)
      CALL FCHAR(X,Y,XCS,YCS,PI/2.)
      WRITE(7,3)
C
C     THIS SECTION WRITES 'PENETRATION-EFFICIENCY' ABOVE GRAPH.
C
      XCS=.12
      YCS=.12
      X=((XMAX-XMIN)/2.)+XMIN-((11.*XCS)/XS)
      Y=YMAX+.75/YS
      CALL FCHAR(X,Y,XCS,YCS,0.)
      WRITE(7,4)
C
C     THIS SECTION WRITES THE GENERAL IDENTIFICATION LABEL IDGEN AND DENSITY
C     RHO ABOVE PLOT AND AT TOP OF PAGE ON LINE PRINTER.
C
      X=XMIN
      Y=YMAX+.5/YS
      XCS=.056
      YCS=.100
      DO 30 I=1,79
      J=80-I
      IF(IDGEN(J).NE.IBLAK)GO TO 40
   30 CONTINUE
      J=1
   40 CALL FCHAR(X,Y,XCS,YCS,0.)
      WRITE(7,5)(IDGEN(I),I=1,J)
      X=XMIN
      Y=YMAX+.25/YS
      CALL FCHAR(X,Y,XCS,YCS,0.)
      WRITE(7,6)RHO
      WRITE(3,7)(IDGEN(I),I=1,J)
      WRITE(3,17)RHO
C
C     THIS STATEMENT WRITES COLUMN HEADINGS - 'INTERVAL','DIAMETER',
C     'AVERAGE EFFICIENCY','UPPER CONFIDENCE LIMIT OF EFFICIENCY' AND
C     'LOWER CONFIDENCE LIMIT OF EFFICIENCY'.
C
      WRITE(3,8)
      ISIG=0
      KSIG=0
C
C     THIS LOOP READS INLET AND OUTLET FILES . CALCULATES,PLOTS, AND GIVES
C     PRINT OUT FOR PERCENT EFFICIENCY.
C
      DO 100 NSLOT=1,100
      RSLOT=NSLOT
      AVEFF=0.0
      CLUF=0.0
      CLLE=0.0
      AVPEN=1.0
      CLUP=1.0
      CLLP=1.0
      NCON=0
C
C     RECORDS ARE READ FROM IFILE UNTIL END OF RECORDS FOR THIS DENSITY
C     IS SIGNALED BY 5 ASTERISKS (DAST). THEN ISIG SET = 1 UNTIL KFILE
C     READINGS ARE COMPLETED. THIS IS DONE LIKEWISE FOR KFILE USING
C     KSIG = 1 IF IFILE SHOULD HAVE MORE RECORDS THAN KFILE.
C
      IF(ISIG.EQ.1)GO TO 45
      READ(16)DPLOT,AVIN,SIGIN,NIN
      IF(DPLOT.EQ.DAST)ISIG=1
   45 IF(KSIG.EQ.1)GO TO 47
      READ(17)DPLOT,AVOUT,SIGOUT,NOUT
      IF(DPLOT.EQ.DAST)KSIG=1
C
C     IF END OF RECORDS FOR THIS DENSITY HAS BEEN REACHED IN BOTH FILES,
C     ISIG = 1 AND KSIG = 1.
C
C     IF END OF RECORDS FOR THIS DENSITY HAS BEEN REACHED IN ONLY ONE
C     OF THE FILES. LOOP CONTINUES TO RETURN AND READ THE LONGER FILE.
C
   47 IF(ISIG+KSIG-1)210,100,150
  210 IF(AVIN*NIN*NOUT)215,215,220
  215 NCON=1
      GO TO 50
  220 AVPEN=AVOUT/AVIN
      AVEFF=1.0-AVPEN
      IF(NIN.EQ.1.OR.NOUT.EQ.1) GO TO 221
      ROUT=NOUT
      RIN=NIN
      TOUT=(0.674+(0.32*((ROUT-1.)**(-1.072))))/SQRT(ROUT)
C
      TIN=(0.674+(0.32*((RIN-1.)**(-1.072))))/SQRT(RIN)
C
      SIGIO=AVPEN*AVPEN*((TOUT*SIGOUT/AVOUT)**2/ROUT+(TIN*SIGIN/AVIN)**2
     1/RIN)
      IF(SIGIO)221,221,225
  221 NCON=1
      GO TO 50
  225 SIGIO=SQRT(SIGIO)
      CLUP=AVPEN+SIGIO
      CLLP= AVPEN-SIGIO
   48 CLUE=1.0-CLLP
      CLLE=1.0-CLUP
C
C     THIS SECTION PLOTS THE AVERAGE PERCENT EFFICIENCY WITH UPPER AND
C     LOWER CONFIDENCE LIMITS VS. PARTICLE DIAMETER.
C
   50 DPLOT=ALOG10(DPLOT)
C
C     FUNCTIONS XVAL AND YVAL CHECK FOR VALUES OUTSIDE PLOTTING GRID.
C     A VALUE .25 INCHES OUTSIDE OF THE GRID IS GIVEN TO ANY SUCH POINTS.
C     OTHERWISE THE VALUE IS NOT CHANGED.
C
      XN=XVAL(DPLOT,XMAX,XMIN,XS)
C
C     IF LOWER CONFIDENCE LIMIT CLLE IS TO BE DRAWN, FIND ITS VALUE
C     IN TERMS OF NORMAL PROBABILITY SCALE.
C
      IF(NCON.NE.0.OR.NSPCON.NE.0) GO TO 327
      IF(CLLP-.0001)305,310,310
  305 YV=-50.0
      GO TO 325
  310 YV=ALOG10(100.0*CLLP)
C
C     CHECK TO SEE THAT LOWER CONFIDENCE LIMIT IS WITHIN PLOTTING
C     LIMITS. DRAW HORIZONTAL LOWER CONFIDENCE LIMIT TICK.
C
  325 YN=YVAL(YV,YMAX,YMIN,YS)
      XN=XN-.03/XS
      CALL FPLOT(-2,XN,YN)
      XN=XN+.06/XS
      CALL FPLOT(0,XN,YN)
      XN=XN-.03/XS
      CALL FPLOT(0,XN,YN)
  327 IF(AVPEN-.0001)330,335,335
  330 YV=-50.0
      GO TO 350
  335 YV=ALOG10(100.0*AVPEN)
C
C     CHECK TO SEE THAT AVERAGE IS WITHIN PLOTTING LIMITS. DRAW
C     VERTICAL BAR FROM LOWER CONFIDENCE LIMIT TO AVERAGE.
C
  350 YN=YVAL(YV,YMAX,YMIN,YS)
      CALL FPLOT(0,XN,YN)
      IF(NCON.NE.0.OR.NSPCON.NE.0) CALL FPLOT(2,XN,YN)
C
C     SUBROUTINE SYMBOL(I,S) DRAWS A SYMBOL DETERMINED BY I (HERE I = 9,
C     THEREFORE DRAWS SOLID CIRCLE) INSIDE A SQUARE OF DIMENSION S.
C
      CALL SYMBOL(9,.04)
C
C     IF UPPER CONFIDENCE LIMIT CLUE IS TO BE DRAWN, FIND ITS VALUE
C     IN TERMS OF NORMAL PROBABILITY SCALE.
C
      IF(NCON.EQ.0.AND.NSPCON.EQ.0)GO TO 354
  353 CALL FPLOT(1,XN,YN)
```

```
      GO TO 55
  354 IF(CLUP-.0001)355,360,360
  355 YV=-50.0
      GO TO 375
  360 YV=ALOG10(100.0*CLUP)
C
C     CHECK TO SEE THAT UPPER CONFIDENCE LIMIT IS WITHIN PLOTTING
C     LIMITS. DRAW VERTICAL BAR FROM AVERAGE TO UPPER CONFIDENCE LIMIT
C     AND DRAW HORIZONTAL TICK.
C
  375 YN=YVAL(YV,YMAX,YMIN,YS)
      CALL FPLOT(0,XN,YN)
      XN=XN-.03/XS
      CALL FPLOT(0,XN,YN)
      XN=XN+.06/XS
      CALL FPLOT(-1,XN,YN)
C
C     THIS LOOP CHANGES FRACTIONAL EFFICIENCY TO PERCENT EFFICIENCY FOR
C     PRINTING.
C
   55 DO 60 I=3,5
      RBUF(I)=RBUF(I)*100.
      IF(RBUF(I).GE.100.0)RBUF(I)=100.0
      IF(RBUF(I).LE.0.0)RBUF(I)=0.0
   60 CONTINUE
C
C     CHANGE FROM LOG10 DIAMETER TO DIAMETER FOR PRINTING.
C
      DPLOT=EXP(2.302585*DPLOT)
C
C     WRITE DIAMETER INDEX NUMBER, DIAMETER, EFFICIENCY, UPPER
C     LIMIT OF EFFICIENCY, AND LOWER LIMIT OF EFFICIENCY.
C
   70 WRITE(3,11)(RBUF(I),I=1,5)
  100 CONTINUE
C
C     RETURN PLOTTER PEN TO BASE LINE 3 INCHES BEYOND GRID. THEN READY
C     FOR NEXT PLOT.
C
  150 XN=XMAX+4.5/XS
      YN=Y0
      CALL FPLOT(0,XN,YN)
  200 CONTINUE
    1 FORMAT(1X,'PERCENT PENETRATION')
    2 FORMAT(1X,'PARTICLE DIAMETER (MICROMETERS)')
    3 FORMAT(1X,'PERCENT EFFICIENCY')
    4 FORMAT(1X,'PENETRATION-EFFICIENCY')
    5 FORMAT(1X,80A1)
    6 FORMAT(1X,'RHO= ',F4.2,' GM/CC')
    7 FORMAT(1H1,1X,80A1)
   17 FORMAT(1X,'RHO= ',F4.2,' GM/CC')
    8 FORMAT(38X,'UPPER CONFIDENCE',3X,'LOWER CONFIDENCE'/,
     127X,'AVERAGE',7X,'LIMIT OF',11X,'LIMIT OF'/,
     23X,'INTERVAL',3X,'DIAMETER',3X,'EFFICIENCY',5X,'EFFICIENCY',
     38X,'EFFICIENCY'/)
   11 FORMAT(6X,F3.0,3X,F8.4.5X,F8.4,7X,F8.4.11X,F8.4)
   12 FORMAT(80A1)
  500 FORMAT(2I2)
  501 FORMAT(2I1)
  510 FORMAT(F5.4)
```

```
      STOP
      END
```


BEGIN PROGRAM SPLIN1
SET INITIAL VALUES, READ NUMBER OF RUNS, NRUN, ON INPUT FILE 10.
DEFINE 8 SUBINTERVALS FROM LAST STAGE D_{50} AND MAXIMUM DIAM. DEFINE 4 SUBINTERVALS BETWEEN EACH STAGE D_{50}.
START LOOP OVER RUN INDEX, IAV. EACH PASS READS A SET OF CUMULATIVE MASS PLUS TOTAL MASS LOADING WITH D_{50} AND MAX DIAM.
A
IS EACH RUN TO BE FIT IN SEQUENCE (OR IS A PARTICULAR RUN TO BE FIT?)
NO
READ SEQUENCE NUMBER OF RUN TO BE FIT.
YES
READ DATA FOR THE RUN, CUMULATIVE MASSES, D_{50}'S ETC.
DEFINE A NEW SET OF DATA POINTS BY TAKING LOG_{10} OF THE CUM. MASSES AND DIAMETERS.
DEFINE, ON A COMMON LOG SCALE, 3 EQUALLY SPACED DIAMETERS BETWEEN EACH D_{50}. DEFINE 2 DIAMETERS BEYOND LOG(DMAX).
MAKE 2ND ORDER OVERLAPPING POLYNOMIAL FITS TO 3 DATA POINTS AT A TIME, i.e., 1, 2, 3; 234, 345, ETC. UNTIL A SET OF CURVE FITS OVER ALL DATA EXISTS.
SUBROUTINE SIMO
CHECK SLOPE AT FITTED POINTS FOR EACH FIT. IF SLOPE 0, REPLACE THAT PART OF THE FIT WITH A STRAIGHT LINE WITH SLOPE 0.
USE CURVE FITS TO DEFINE Y VALUES FOR THE SPACED X-VALUES (DIAMETERS) DEFINED ABOVE.
GO TO 1

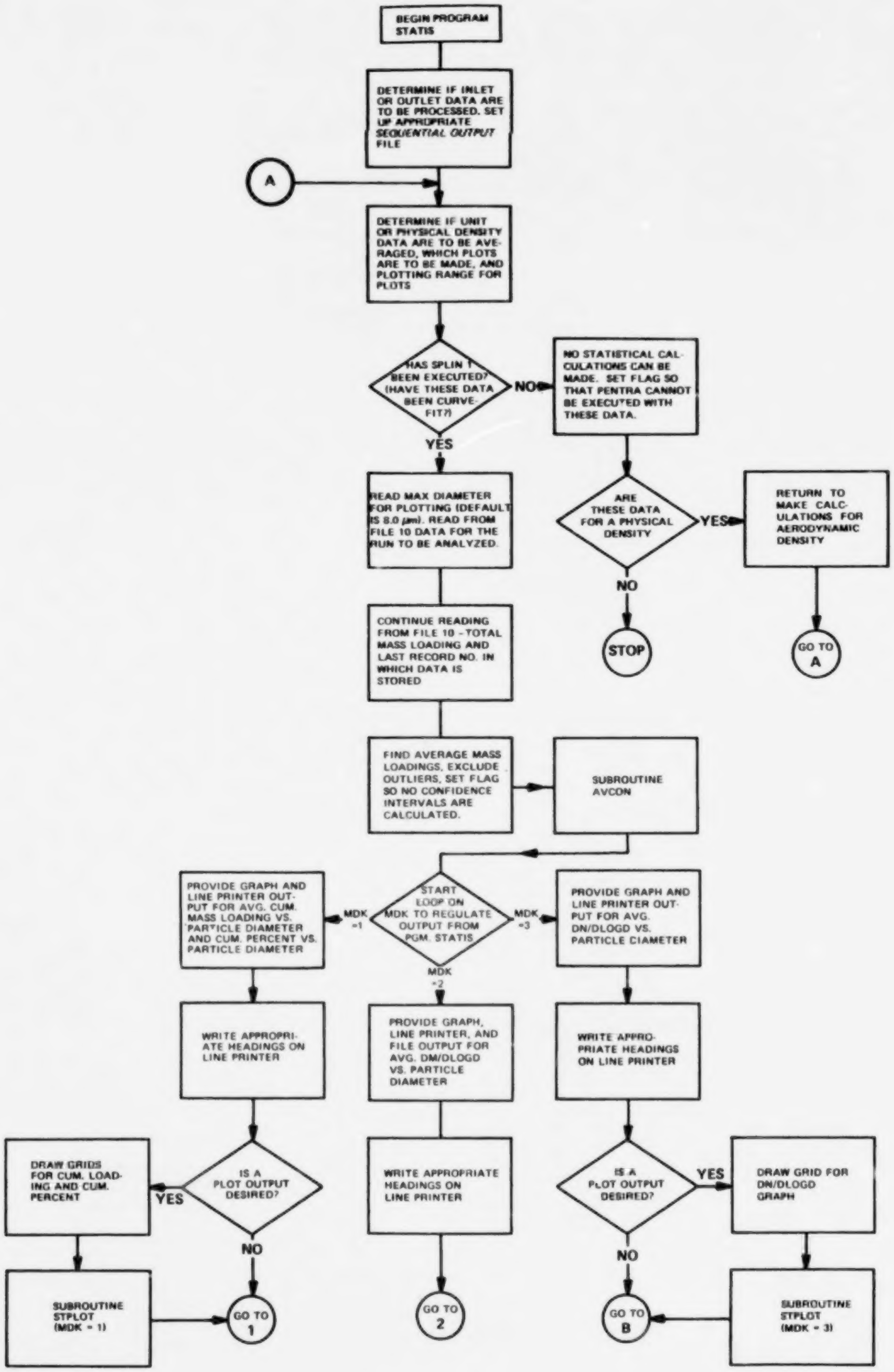

1
FIT PARABOLA THROUGH FIRST 3 POINTS - ONE REAL, TWO INTERPOLATED.
SUBROUTINE SIMQ
IS SLOPE AT FIRST POINT >0
NO
ADD A FICTITIOUS POINT TO THE LEFT OF THE FIRST POINT WITH A Y VALUE OF THE SECOND (INTERPOLATED) POINT.
YES
B
FIT PARABOLA THROUGH FICTITIOUS POINT, FIRST POINT AND SECOND POINT.
SUBROUTINE SIMQ
FIND FITTING PARABOLA FOR EACH INTERVAL BETWEEN THE TWO BOUNDARY POINTS. REQUIRE FOLLOWING CONDITIONS FOR FIT
1. FIT CONTINUOUS ACROSS INTERVAL BOUNDARY
2. FIT FIRST DERIVATIVE CONTINUOUS ACROSS INTERVAL BOUNDARY
3. FITTING PARABOLA FOR AN INTERVAL PASSES THROUGH 2ND POINT PAST THIS INTERVAL
MAKE CURVE FIT FOR INTERVAL
SUBROUTINE SIMQ
SAVE CURVE FIT COEFFICIENTS FOR EACH INTERVAL.
GO TO NEXT INTERVAL
NO
WAS THIS THE LAST INTERVAL TO BE FITTED?
YES
DID THIS INTERVAL END AT DMAX?
YES
NO
DEFINE A HYPERBOLA BETWEEN DMAX AND D50 OF THE FIRST STAGE.
GO TO 2
DEFINE NO. INTERVALS = NO. FITTED POINTS-1 AND WRITE THIS NO. OF FITTED BOUNDARY POINTS, POINT VALUES, AND FITTING COEFFICIENT VALUES FOR THIS RUN IN ONE RECORD OF FILE 11.
HAVE ALL RUNS BEEN CHECKED TO FIT CUM. MASS LOADING?
NO
GO TO A
YES
STOP
2
ON HYPERBOLA, DEFINE 8 EQUALLY SPACED POINTS FROM D50 1ST STAGE TO DMAX, AND 2 POINTS BEYOND DMAX
FOLLOW SAME PROCEDURE AS ABOVE TO FIT A PARABOLA TO EACH INTERVAL BETWEEN ANY TWO POINTS ON HYPERBOLA FROM D50 FIRST STAGE TO DMAX.
GO TO B

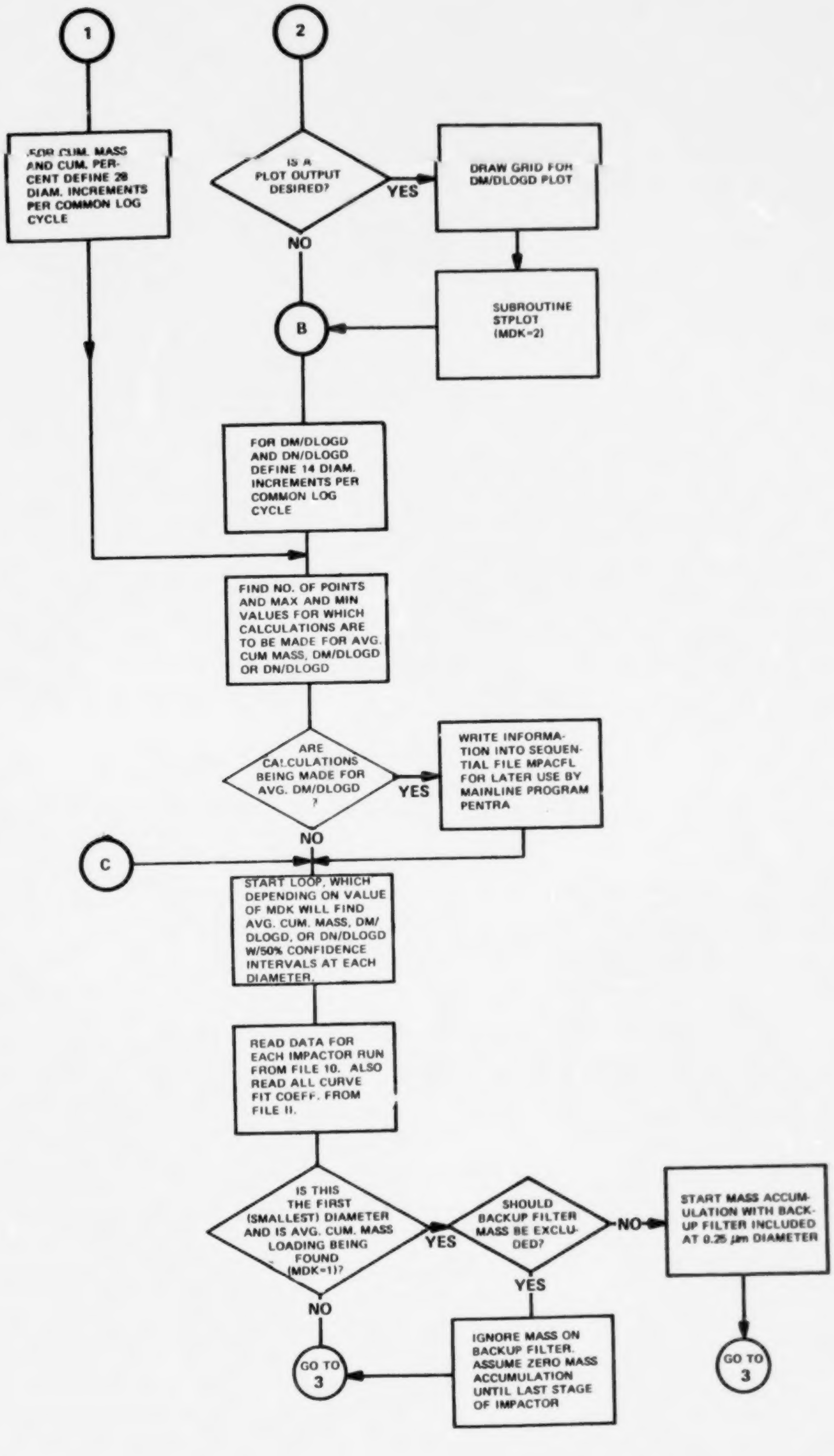
```
C     MAIN PROGRAM SPLIN1
C**************************************************************************
C*
C*     PROGRAM SPLIN1 FITS LOG10(CUMULATIVE MASS LOADING) VS LOG10(D50)
C*     WITH A SERIES OF OVER LAPPING, CONTINUOUS 2ND DEGREE POLYNOMIALS.
C*     BOTH THE POLYNOMIALS AND THEIR 1ST DERIVATIVES ARE CONTINUOUS.
C*
C**************************************************************************
C
      INTEGER VV
      DOUBLE PRECISION DLOG10,XNDPEN(10),YD(10)
      DOUBLE PRECISION XINC,YINC
      DIMENSION ID(80),DPC(8),CUMG(8),DMDLD(9),GEOMD(9),DNDLD(9)
      DIMENSION X(51),Y(51),A(16),B(4),COE(50,3),COE1(50,3)
      DIMENSION X1(51),Y1(51)
      DIMENSION FILSPL(2),FILNAM(2)
      DIMENSION AA(9),BB(3)
      EQUIVALENCE (X,X1),(Y,Y1),(COE,COE1)
      DATA FILNAM/'KMC00','1BIN'/
      DATA FILSPL/'FILSP','LBIN'/
      CALL DEFINE(10,251,101,FILNAM,I10,0,0,0)
      CALL DEFINE(11,507,100,FILSPL,I10,0,0,0)
C
C     RECORD 101 CONTAINS GENERAL INFORMATION PERTAINING
C     TO ALL RUNS, NRUN=NO. OF RUNS (2 RECORDS FOR EACH RUN)
C      ISFIN = LAST RECORD NUMBER CONTAINING INDIVIDUAL RUN DATA
C      IN FILE 10.
      READ(10'101)NRUN
      ISFIN = NRUN*2
C
C      KREAD = 0 - MAKE FIT TO ALL SETS OF CUM. MASS LOADING VS D50
C      VALUES OF FILE. KREAD NOT = 0 - READ IN SETS TO BE FITTED.
C
      READ(2,1)KREAD
C
C      NN = NUMBER OF SUBINTERVALS TO BE SET UP IN LAST INTERVAL
C      BETWEEN D50 OF 1ST STAGE AND DMAX.
C      N = NUMBER OF SUBINTERVALS TO BE SET UP BETWEEN EACH PAIR OF
C      D50'S UP TO D50 OF 1ST STAGE.
C
  307 NN=8
      RR=NN
      N=4
      R=N
      DO 400 INDEX=1,ISFIN
      IAV=INDEX
C
C      IF KREAD NOT = 0, READ RECORD NO. IAV FOR DATA TO BE FITTED.
C      ALSO, IF KREAD NOT = 0, LEAVE LAST CARD BLANK TO STOP.
C
      IF(KREAD)310,310,2
    2 READ(2,1)IAV
      IF(IAV.EQ.0)STOP
C
C      VALUES TO BE USED FROM READING OF RECORD ARE:
C        NFIT - NUMBER OF CUMULATIVE MASS LOADING VS. D50 POINTS (+1
C              FOR TOTAL MASS LOADING VS. MAXIMUM DIAMETER) TO BE
C              FITTED.
C        XNDPEN(I),I=1,NFIT - SET OF D50 VALUES AND MAXIMUM DIAMETER.
```

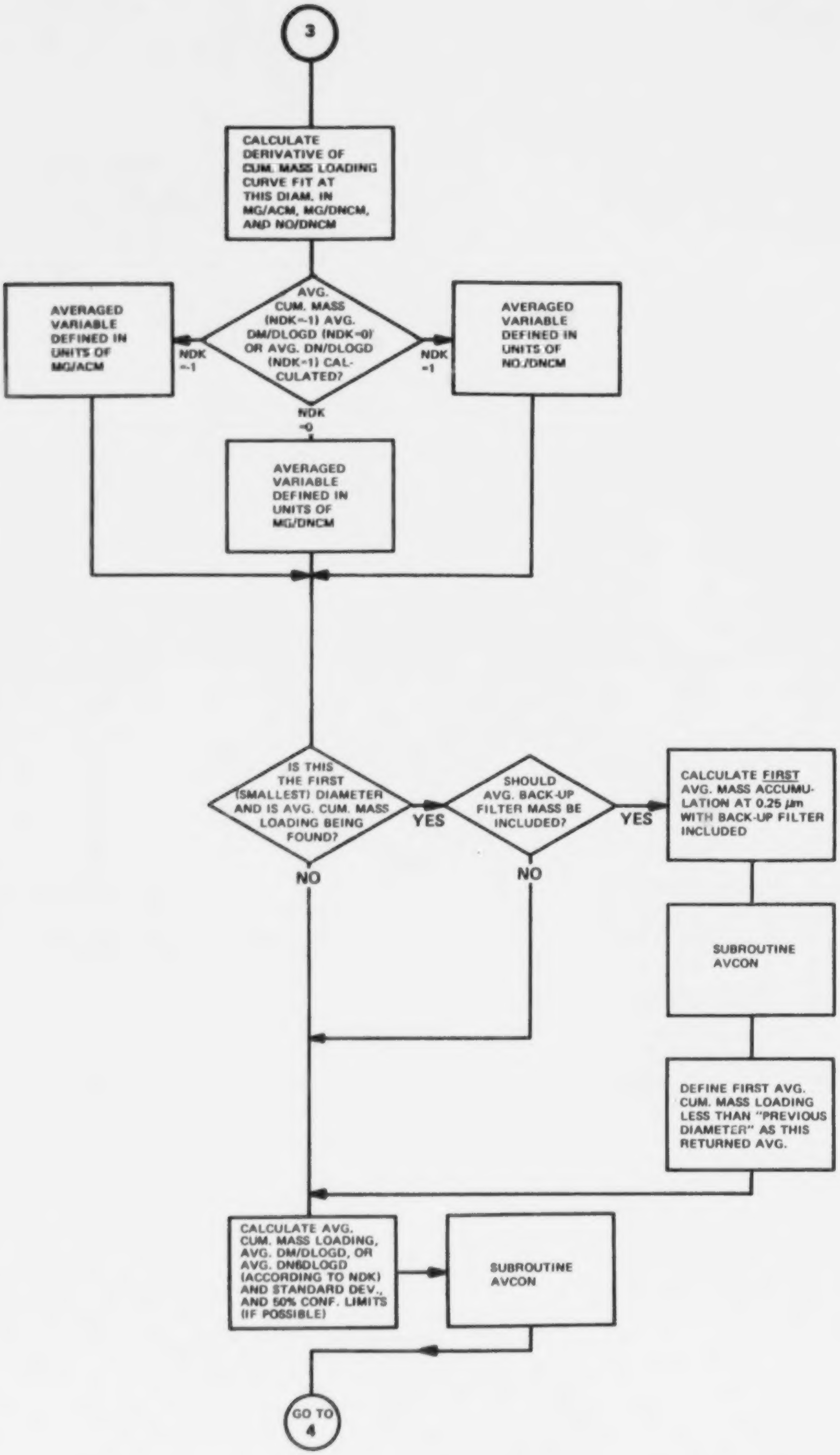
```
C         YO(I),I=1,NFIT - SET OF MASS LOADING VALUES.
C       OTHER VALUES READ HERE ARE NOT USED.
C
  310 READ(10'IAV)IS,NFIT,GRNAM,ID,RHO,TKS,POA,FGH2O,DSMA,DMAX,
     1DPC,CUMG,DMDLD,GEOMD,DNDLD,CYC3,MC3,MOO,MS,VV,
     2(XNDPEN(I),I=1,NFIT),(YO(I),I=1,NFIT)
C
C       NFIT1 = NUMBER OF CUMULATIVE MASS LOADING VS. D50 POINTS
C       (EXCLUDES TOTAL LOADING VS. DMAX).
C       NPT = TOTAL NUMBER OF POINTS USED FOR FITTING BETWEEN (AND
C       INCLUDING) MAXIMUM PARTICLE SIZE AND D50 OF LAST STAGE.
C
      NFIT1=NFIT-1
      NPT=((NFIT1-1)*N)+NN+1
      NFIT2=NFIT-2
C
C       THIS ''DO 100'' LOOP FITS A 2ND DEGREE POLYNOMIAL TO 3
C       LOG10(CUMULATIVE MASS LOADING) VS. LOG10(D50) POINTS ON EACH
C       TRAVERSE, IE.:
C       LOG10 OF (XNDPEN(1),YO(1)),(XNDPEN(2),YO(2)),(XNDPEN(3),YO(3));
C         ''  '' (XNDPEN(2),YO(2)),(XNDPEN(3),YO(3)),(XNDPEN(4),YO(4));
C       ;.............................................................;
C         ''  '' (XNDPEN(NFIT2),YO(NFIT2)),(XNDPEN(NFIT1),YO(NFIT1)),
C       (XNDPEN(NFIT),YO(NFIT))
C       IF THE FITTING POLYNOMIAL HAS NON-NEGATIVE SLOPE AT BOTH
C       LOG10(XNDPEN(I),YO(I)) AND LOG10(XNDPEN(I+1),YO(I+1)), THE
C       FITTING COEFFICIENTS ARE USED BETWEEN THESE 2 POINTS TO DEFINE
C       3 INTERMEDIATE POINTS EVENLY SPACED ON LOG10 SCALE. IF THERE IS A
C       NEGATIVE SLOPE AT EITHER OF THESE 2 POINTS, A STRAIGHT LINE FIT
C       BETWEEN THE POINTS IS USED TO DEFINE THE 3 INTERMEDIATE POINTS.
C       THE VECTORS X1 AND Y1 REPRESENT LOG10 OF ORIGINAL CUM. MASS
C       LOADING VS. D50 POINTS AND THE FABRICATED INTERMEDIATE POINTS.
C
C       THE NUMBER OF POINTS REPRESENTED BY THE X1, Y1 VECTORS IS
C       (NFIT2*4)+1+2. THERE ARE (NFIT2*4)+1 POINTS BETWEEN POINTS AT
C       LOG10(D50) OF LAST STAGE AND LOG10(D50) OF 1ST STAGE INCLUSIVE.
C       2 MORE ARE EXTRAPOLATED BEYOND LOG10(D50) OF 1ST STAGE.
C
      DO 100 I=1,NFIT2
      JJ=N-1
      IF(NFIT2-I)90,80,80
   80 JJ=N+2
   90 M=(I-1)*N+1
      X1(M)=DLOG10(XNDPEN(I))
      Y1(M)=DLOG10(YO(I))
      XINC=(DLOG10(XNDPEN(I+1))-DLOG10(XNDPEN(I)))/R
C
C       SIMQ SOLVES N SIMULTANEOUS LINEAR EQUATIONS, AX = B. HERE
C       N = 3. THE MATRIX OF COEFFICIENTS, A, IS DESTROYED IN THE
C       COMPUTATION. THE VECTOR OF ORIGINAL CONSTANTS, B, IS REPLACED
C      BY THE FINAL SOLUTION VALUES, VECTOR X. COEFFICIENT MATRIX A AND
C       CONSTANT VECTOR B ARE DEFINED IN THIS LOOP.
C
      DO 1100 II=1,3
      MM=I-1+II
      B(II)=DLOG10(YO(MM))
      K=3*(II-1)
      DO 1100 J=1,3
      M3=I-1+J
 1100 A(K+J)=DLOG10(XNDPEN(M3))**(II-1)
```

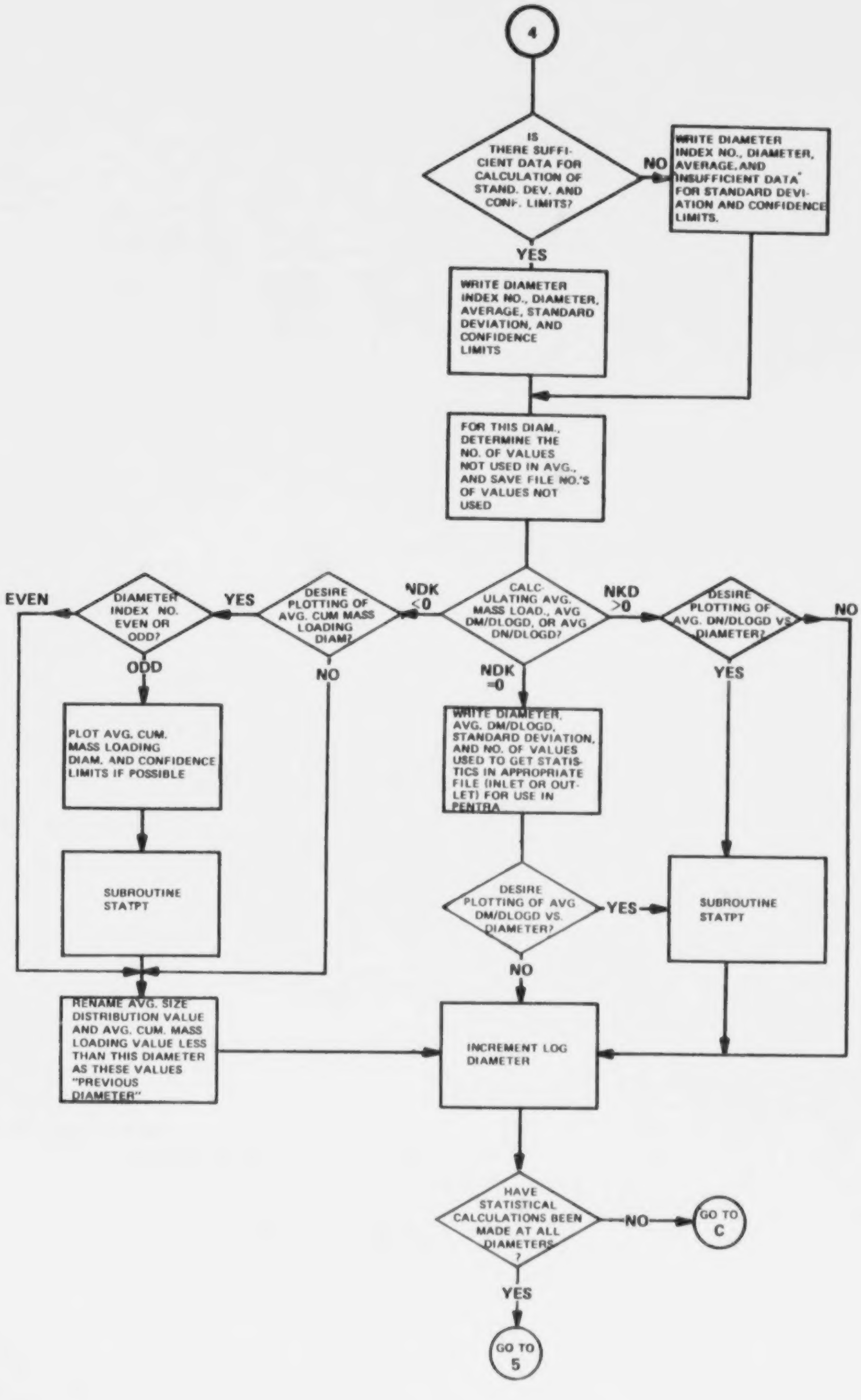
```
      KS=0
      CALL SIMQ(A,B,3,KS)
C
C      USE STRAIGHT LINE FIT, NOT POLY FIT, IF NEGATIVE SLOPE AT EITHER
C      END OF ORIGINAL INTERVAL.
C
      DO 1119 J=1,2
      SLOPE=B(2)+2.0*B(3)*DLOG10(XNDPEN(I+J-1))
      IF(SLOPE)1104,1119,1119
 1104 B(2)=(DLOG10(YD(I+1)/YD(I)))
     1/(DLOG10(XNDPEN(I+1)/XNDPEN(I)))
      B(1)=DLOG10(YD(I))-B(2)*DLOG10(XNDPEN(I))
      B(3)=0.0
      GO TO 1120
 1119 CONTINUE
 1120 DO 100 J=1,JJ
      K=M+J
      X1(K)=DLOG10(XNDPEN(I))+J*XINC
      Y1(K)=B(1)+B(2)*X1(K)+B(3)*X1(K)**2
  100 CONTINUE
C
C      FIT THE FIRST 3 (X,Y) POINTS WITH A 2ND DEGREE POLYNOMIAL IN
C      ORDER TO DEFINE SLOPE AT (X(1),Y(1)). (NOTE - (X1,Y1) POINTS ARE
C      EQUIVALENT TO (X,Y) POINTS!!!)
C
  104 DO 110 I=1,3
      K=3*(I-1)
      DO 110 J=1,3
      M=1+(J-1)*N
  110 A(K+J)=X(M)**(I-1)
      DO 115 I=1,3
      M=1+(I-1)*N
  115 B(I)=Y(M)
      KS=0
      CALL SIMQ(A,B,3,KS)
C
C      CHECK THE SLOPE OF THIS CURVE FIT AT THE FIRST POINT. IF IT IS
C      NEGATIVE, ADD A POINT ON THE OTHER SIDE OF POINT 1 FROM THE
C      2ND POINT A DISTANCE (X(2)-X(1)) FROM X(1). THE Y COORDINATE
C      VALUE IS SET = TO Y(1). THE POLYNOMIAL FIT THROUGH THIS POINT,
C      (X(1),Y(1)), AND (X(2),Y(2)) MUST HAVE POSITIVE SLOPE AT
C      (X(1),Y(1)).
C
      SLOPE=B(2)+2.0*B(3)*X(1)
      IF(SLOPE)4,19,19
    4 DO 5 I=1,3
    5 A(I)=1
      A(4)=X(1)-(X(N+1)-X(1))
      A(7)=(A(4))**2
      DO 10 I=1,2
      K=3*I
      DO 10 J=2,3
      M=1+((J-2)*N)
   10 A(K+J)=X(M)**I
      B(1)=Y(1)
      DO 15 I=2,3
      M=1+((I-2)*N)
   15 B(I)=Y(M)
      KS=0
      CALL SIMQ(A,B,3,KS)
   19 DO 20 I=1,3
   20 COE(1,I)=B(I)
C
C       II = FIRST INTERVAL FOR WHICH FITTING COEFFICIENTS ARE DEFINED.
C       INTS1 = LAST INTERVAL WHERE POLYNOMIAL FITS WERE USED TO FABRI-
C       CATE INTERMEDIATE POINTS, THE UPPER BOUNDARY OF THIS INTERVAL
C      IS LOG10(XNDPEN(NFIT1),YO(NFIT1)) HERE.
C
      II=1
      INTS1=NPT-NN-1
C
C        THIS LOOP FINDS THE FITTING COEFFICIENTS FOR EACH INTERVAL. THE
C        3 EQUATIONS ARE SOLVED FOR 3 UNKNOWN COEFFICIENT VALUES FOR THE
C        FITTING 2ND DEGREE POLYNOMIAL. THE EQUATIONS EXPRESS 3
C        CONDITIONS FOR THE FIT:
C          1.   THE FITTING POLYNOMIALS OF THE 2 JOINING INTERVALS ARE
C               CONTINUOUS AT THE MUTUAL BOUNDARY POINT.
C          2.   THE FIRST DERIVATIVES SAME ARE CONTINUOUS AT THE
C               MUTUAL BOUNDARY POINT.
C          3.   THE FITTING POLYNOMIAL OF THIS I TH INTERVAL (FITTING
C               BETWEEN POINTS I AND I+1) GOES THROUGH THE (I+4)TH POINT,
C               I.E. A POINT OUTSIDE THE INTERVAL. FITTING ROUTINE ''LOOKS
C               AHEAD'' TO LET COMING POINTS INFLUENCE CURVE DIRECTION.
C
   23 DO 50 I=II,INTS1
      JJ=I
      B(1)=0.0
      DO 25 J=2,3
      K=I-1
      IF(I.EQ.1)K=I
   25 B(1)=B(1)+(J-1)*(COE(K,J))*X(I)**(J-2)
      B(2)=COE(K,1)
      DO 30 J=2,3
   30 B(2)=B(2)+COE(K,J)*X(I)**(J-1)
      B(3)=Y(I+3)
      DO 35 J=1,3
      L=1+(J-1)*3
   35 A(L)=(J-1)*X(I)**(J-2)
      DO 40 J=1,3
      K=J-1
      KK=3*K
   40 A(KK+2)=X(I)**K
      DO 43 J=1,3
      K=J-1
      KK=3*K
   43 A(KK+3)=X(I+3)**K
      KS=0
      CALL SIMQ(A,B,3,KS)
C
C        SAVE THE FITTING COEFFICIENT VECTOR B WHICH FITS OVER INTERVAL
C        I AS COE.
C
      DO 45 J=1,3
      COE(I,J)=B(J)
   45 CONTINUE
   50 CONTINUE
      IF(JJ.EQ.(NPT-1))GO TO 55
C
C        THE LAST SERIES OF INTERVALS FOR WHICH FITTING COEFFICIENTS ARE
C        TO BE DEFINED LIES BETWEEN LOG10(XNDPEN(NFIT1),YO(NFIT1)) AND
```

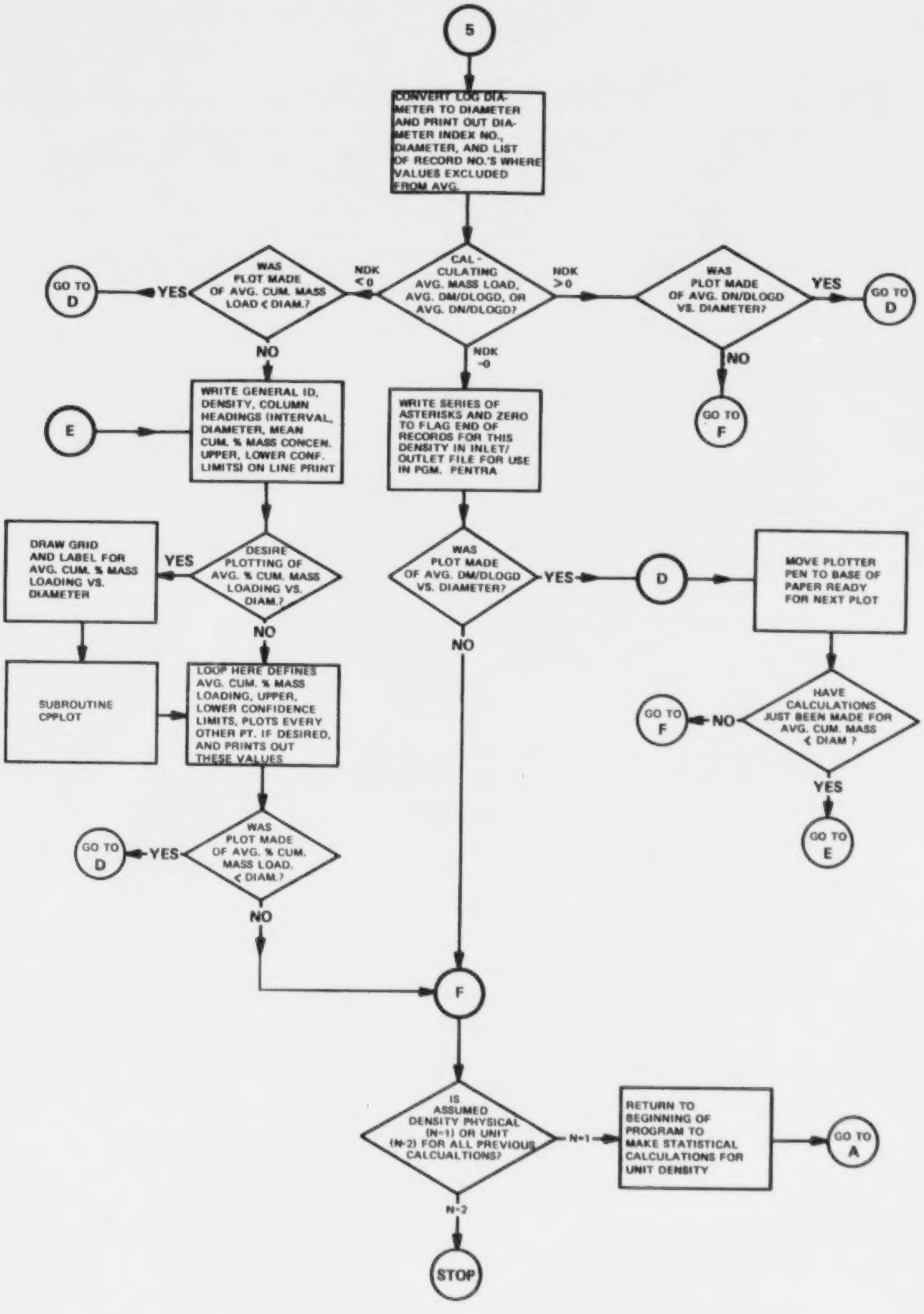
```
C        LOG10(XNDPEN(NFIT),YO(NFIT)). THE POINTS ARE DEFINED ALONG
C        AN HYPERBOLA BETWEEN THESE 2 POINTS OF THE FORM LOG10(Y) =
C        B(1) + B(2) / X.
C
      HYPL=DLOG10(XNDPEN(NFIT))-DLOG10(XNDPEN(NFIT1))
      XINC=HYPL/RR
      M=(NFIT1-1)*N+1
      XSUB1=1.D0/XNDPEN(NFIT1)
      YSUB1=Y1(M)
      XSUB2=1.D0/XNDPEN(NFIT)
      YSUB2=DLOG10(YO(NFIT))
      B(2)=(YSUB2-YSUB1)/(XSUB2-XSUB1)
      B(1)=YSUB1-B(2)*XSUB1
C
C        THE NUMBER OF POINTS TO BE USED ALONG THE HYPERBOLA IS NN+2 = 8+2.
C        THE 2 ADDED POINTS ARE EXTRAPOLATED VALUES BEYOND
C        LOG10(XNDPEN(NFIT),YO(NFIT)).
C
      N3=NN+2
      DO 1150 I=1,N3
      J=M+I
      X1(J)=X1(M)+I*XINC
      Y1(J)=B(1)+B(2)*(1.0/(10.0**X1(J)))
 1150 CONTINUE
C
C        REDEFINE ''DO 50'' LOOP INDEX BEGINNING AND END. BEGINNING
C        INTERVAL II IS FIRST INTERVAL OF HYPERBOLA, BEGINS AT D50 OF 1ST
C        STAGE. LAST INTERVAL, INTS1, ENDS WITH DMAX. RETURN TO TOP OF
C        LOOP TO FIND FITTING POLYNOMIAL COEFFICIENTS OVER THESE INTERVALS.
C
      II=NPT-NN
      INTS1=NPT-1
      GO TO 23
C
C        INT = NUMBER OF INTERVALS FOR WHICH FITTING COEFFICIENTS HAVE
C        BEEN DEFINED.
C
   55 INT=NPT-1
C
C        FILE NUMBER OF FITTED POINTS, THE INTERVAL BOUNDARY POINT
C        VALUES, AND FITTING COEFFICIENTS FOR EACH INTERVAL.
C
      WRITE(11'IAV)NPT,(X1(I),I=1,NPT),(Y1(I),I=1,NPT),
     1((COE1(I,J),J=1,3),I=1,INT)
  400 CONTINUE
    1 FORMAT (3I2)
      END
```


BEGIN PROGRAM STATIS
DETERMINE IF INLET OR OUTLET DATA ARE TO BE PROCESSED. SET UP APPROPRIATE SEQUENTIAL OUTPUT FILE
A
DETERMINE IF UNIT OR PHYSICAL DENSITY DATA ARE TO BE AVERAGED, WHICH PLOTS ARE TO BE MADE, AND PLOTTING RANGE FOR PLOTS
HAS SPLIN 1 BEEN EXECUTED? (HAVE THESE DATA BEEN CURVE-FIT?)
NO
NO STATISTICAL CALCULATIONS CAN BE MADE. SET FLAG SO THAT PENTRA CANNOT BE EXECUTED WITH THESE DATA.
YES
READ MAX DIAMETER FOR PLOTTING (DEFAULT IS 8.0 μm). READ FROM FILE 10 DATA FOR THE RUN TO BE ANALYZED.
ARE THESE DATA FOR A PHYSICAL DENSITY
YES
RETURN TO MAKE CALCULATIONS FOR AERODYNAMIC DENSITY
NO
STOP
GO TO A
CONTINUE READING FROM FILE 10 - TOTAL MASS LOADING AND LAST RECORD NO. IN WHICH DATA IS STORED
FIND AVERAGE MASS LOADINGS, EXCLUDE OUTLIERS, SET FLAG SO NO CONFIDENCE INTERVALS ARE CALCULATED.
SUBROUTINE AVCON
PROVIDE GRAPH AND LINE PRINTER OUTPUT FOR AVG. CUM. MASS LOADING VS. PARTICLE DIAMETER AND CUM. PERCENT VS. PARTICLE DIAMETER
MDK =1
START LOOP ON MDK TO REGULATE OUTPUT FROM PGM. STATIS
MDK =3
PROVIDE GRAPH AND LINE PRINTER OUTPUT FOR AVG. DN/DLOGD VS. PARTICLE CIAMETER
MDK =2
WRITE APPROPRIATE HEADINGS ON LINE PRINTER
PROVIDE GRAPH, LINE PRINTER, AND FILE OUTPUT FOR AVG. DM/DLOGD VS. PARTICLE DIAMETER
WRITE APPROPRIATE HEADINGS ON LINE PRINTER
DRAW GRIDS FOR CUM. LOADING AND CUM. PERCENT
YES
IS A PLOT OUTPUT DESIRED?
WRITE APPROPRIATE HEADINGS ON LINE PRINTER
IS A PLOT OUTPUT DESIRED?
YES
DRAW GRID FOR DN/DLOGD GRAPH
NO
NO
SUBROUTINE STPLOT (MDK = 1)
GO TO 1
GO TO 2
GO TO B
SUBROUTINE STPLOT (MDK = 3)


1
2
FOR CUM. MASS AND CUM. PERCENT DEFINE 28 DIAM. INCREMENTS PER COMMON LOG CYCLE
IS A PLOT OUTPUT DESIRED?
YES
NO
DRAW GRID FOR DM/DLOGD PLOT
SUBROUTINE STPLOT (MDK=2)
B
FOR DM/DLOGD AND DN/DLOGD DEFINE 14 DIAM. INCREMENTS PER COMMON LOG CYCLE
FIND NO. OF POINTS AND MAX AND MIN VALUES FOR WHICH CALCULATIONS ARE TO BE MADE FOR AVG. CUM MASS, DM/DLOGD OR DN/DLOGD
ARE CALCULATIONS BEING MADE FOR AVG. DM/DLOGD ?
YES
NO
WRITE INFORMATION INTO SEQUENTIAL FILE MPACFL FOR LATER USE BY MAINLINE PROGRAM PENTRA
C
START LOOP, WHICH DEPENDING ON VALUE OF MDK WILL FIND AVG. CUM. MASS, DM/DLOGD, OR DN/DLOGD W/50% CONFIDENCE INTERVALS AT EACH DIAMETER.
READ DATA FOR EACH IMPACTOR RUN FROM FILE 10. ALSO READ ALL CURVE FIT COEFF. FROM FILE 11.
IS THIS THE FIRST (SMALLEST) DIAMETER AND IS AVG. CUM. MASS LOADING BEING FOUND (MDK=1)?
YES
NO
SHOULD BACKUP FILTER MASS BE EXCLUDED?
NO
YES
START MASS ACCUMULATION WITH BACKUP FILTER INCLUDED AT 0.25 μm DIAMETER
IGNORE MASS ON BACKUP FILTER. ASSUME ZERO MASS ACCUMULATION UNTIL LAST STAGE OF IMPACTOR
GO TO 3
GO TO 3


3
CALCULATE DERIVATIVE OF CUM. MASS LOADING CURVE FIT AT THIS DIAM. IN MG/ACM, MG/DNCM, AND NO/DNCM
AVG. CUM. MASS (NDK=-1) AVG. DM/DLOGD (NDK=0) OR AVG. DN/DLOGD (NDK=1) CALCULATED?
NDK =-1
AVERAGED VARIABLE DEFINED IN UNITS OF MG/ACM
NDK =1
AVERAGED VARIABLE DEFINED IN UNITS OF NO./DNCM
NDK =0
AVERAGED VARIABLE DEFINED IN UNITS OF MG/DNCM
IS THIS THE FIRST (SMALLEST) DIAMETER AND IS AVG. CUM. MASS LOADING BEING FOUND?
YES
NO
SHOULD AVG. BACK-UP FILTER MASS BE INCLUDED?
YES
NO
CALCULATE FIRST AVG. MASS ACCUMULATION AT 0.25 μm WITH BACK-UP FILTER INCLUDED
SUBROUTINE AVCON
DEFINE FIRST AVG. CUM. MASS LOADING LESS THAN "PREVIOUS DIAMETER" AS THIS RETURNED AVG.
CALCULATE AVG. CUM. MASS LOADING, AVG. DM/DLOGD, OR AVG. DN6DLOGD (ACCORDING TO NDK) AND STANDARD DEV., AND 50% CONF. LIMITS (IF POSSIBLE)
SUBROUTINE AVCON
GO TO 4


4
IS THERE SUFFICIENT DATA FOR CALCULATION OF STAND. DEV. AND CONF. LIMITS?
NO
WRITE DIAMETER INDEX NO., DIAMETER, AVERAGE, AND "INSUFFICIENT DATA" FOR STANDARD DEVIATION AND CONFIDENCE LIMITS.
YES
WRITE DIAMETER INDEX NO., DIAMETER, AVERAGE, STANDARD DEVIATION, AND CONFIDENCE LIMITS
FOR THIS DIAM., DETERMINE THE NO. OF VALUES NOT USED IN AVG., AND SAVE FILE NO.'S OF VALUES NOT USED
CALCULATING AVG. MASS LOAD., AVG DM/DLOGD, OR AVG DN/DLOGD?
NDK <0
DESIRE PLOTTING OF AVG. CUM MASS LOADING DIAM?
YES
DIAMETER INDEX NO. EVEN OR ODD?
EVEN
ODD
NO
PLOT AVG. CUM. MASS LOADING DIAM. AND CONFIDENCE LIMITS IF POSSIBLE
SUBROUTINE STATPT
RENAME AVG. SIZE DISTRIBUTION VALUE AND AVG. CUM. MASS LOADING VALUE LESS THAN THIS DIAMETER AS THESE VALUES "PREVIOUS DIAMETER"
NDK =0
WRITE DIAMETER, AVG. DM/DLOGD, STANDARD DEVIATION, AND NO. OF VALUES USED TO GET STATISTICS IN APPROPRIATE FILE (INLET OR OUTLET) FOR USE IN PENTRA
DESIRE PLOTTING OF AVG DM/DLOGD VS. DIAMETER?
YES
SUBROUTINE STATPT
NO
NKD >0
DESIRE PLOTTING OF AVG. DN/DLOGD VS DIAMETER?
YES
NO
INCREMENT LOG DIAMETER
HAVE STATISTICAL CALCULATIONS BEEN MADE AT ALL DIAMETERS ?
NO
GO TO C
YES
GO TO 5


5
CONVERT LOG DIAMETER TO DIAMETER AND PRINT OUT DIAMETER INDEX NO., DIAMETER, AND LIST OF RECORD NO.'S WHERE VALUES EXCLUDED FROM AVG.
CALCULATING AVG. MASS LOAD, AVG. DM/DLOGD, OR AVG. DN/DLOGD?
NDK < 0
NDK > 0
NDK = 0
WAS PLOT MADE OF AVG. CUM. MASS LOAD < DIAM.?
YES
GO TO D
NO
WAS PLOT MADE OF AVG. DN/DLOGD VS. DIAMETER?
YES
GO TO D
NO
GO TO F
WRITE GENERAL ID, DENSITY, COLUMN HEADINGS (INTERVAL, DIAMETER, MEAN CUM. % MASS CONCEN. UPPER, LOWER CONF. LIMITS) ON LINE PRINT
E
WRITE SERIES OF ASTERISKS AND ZERO TO FLAG END OF RECORDS FOR THIS DENSITY IN INLET/ OUTLET FILE FOR USE IN PGM. PENTRA
DRAW GRID AND LABEL FOR AVG. CUM. % MASS LOADING VS. DIAMETER
YES
DESIRE PLOTTING OF AVG. % CUM. MASS LOADING VS. DIAM.?
NO
WAS PLOT MADE OF AVG. DM/DLOGD VS. DIAMETER?
YES
D
MOVE PLOTTER PEN TO BASE OF PAPER READY FOR NEXT PLOT
NO
SUBROUTINE CPPLOT
LOOP HERE DEFINES AVG. CUM. % MASS LOADING, UPPER, LOWER CONFIDENCE LIMITS, PLOTS EVERY OTHER PT. IF DESIRED, AND PRINTS OUT THESE VALUES
HAVE CALCULATIONS JUST BEEN MADE FOR AVG. CUM. MASS < DIAM ?
NO
GO TO F
YES
GO TO E
WAS PLOT MADE OF AVG. % CUM. MASS LOAD. < DIAM.?
YES
GO TO D
NO
F
IS ASSUMED DENSITY PHYSICAL (N=1) OR UNIT (N=2) FOR ALL PREVIOUS CALCUALTIONS?
N=1
RETURN TO BEGINNING OF PROGRAM TO MAKE STATISTICAL CALCULATIONS FOR UNIT DENSITY
GO TO A
N=2
STOP

```
C     MAIN PROGRAM STATIS
C***********************************************************************
C*
C*      PROGRAM STATIS CALCULATES AVERAGE VALUES FOR CUMULATIVE MASS
C*      LOADING, CUMULATIVE PERCENT MASS LOADING, MASS SIZE DISTRIBUTION,
C*      AND NUMBER SIZE DISTRIBUTION OVER A DIAMETER RANGE OF .25 MICRONS
C*      TO 8.0 MICRONS (FOR PHYSICAL DENSITY), 10.0 MICRONS (FOR
C*      AERODYNAMIC DENSITY), OR SOME OTHER SPECIFIED SIZE. STATIS ALSO
C*     CALCULATES 50 PERCENT CONFIDENCE LIMITS FOR THESE. PROGRAM
C*      OUTPUTS TABLES AND GRAPHS (IF DESIRED) . ALSO, LISTING IS MADE
C*      OF ANY OUTLYING DATA WHICH HAS BEEN EXCLUDED FROM AVERAGING
C*      AND CALCULATION OF CONFIDENCE LIMITS.
C*
C***********************************************************************
C
      INTEGER VV,THROUT(60,50)
      DOUBLE PRECISION XNDPEN(10),YO(10)
      DIMENSION DPC(8),GEOMD(9),DMDLD(9),DNDLD(9),CUMG(8),ID(80)
      DIMENSION IDALL(80),GEMAX(2),GEMIN(2),DMMAX(2),DMMIN(2)
      DIMENSION DNMAX(2),DNMIN(2),DPMAX(2),DPMIN(2),CUMAX(2),CUMIN(2)
      DIMENSION DEL(100)
      DIMENSION TGL(100),GLMIN(50),ATGL(2),CUM2D(60),NOCON(60),CLU(60)
      DIMENSION CLL(60),AGLMIN(2)
      DIMENSION NOUT(60),CUCON1(100),CUCON(2)
      DIMENSION FILNAM(2),FILNM1(2),FILNM2(2)
      DIMENSION IDBLAK(80)
      DIMENSION FILSPL(2),COE(50,3),X1(51),Y1(51)
      DATA FILNAM/'KMC00','1BIN'/
      DATA FILNM1/'JWJ00','1BIN'/
      DATA FILNM2/'JWJ00','2BIN'/
      DATA FILSPL/'FILSP','LBIN'/
      DATA DAST/'*****'/
      DATA IDBLAK/80*0/
      DATA IBLAK/0/
      DATA BLAK/0.0/
      CALL DEFINE(10,251,101,FILNAM,I10,0,0,0)
      CALL DEFINE(11,507,100,FILSPL,I10,0,0,0)
C
C     INOUT =1FOR INLET DATA, 2 FOR OUTLET DAT
C
      READ(2,800)INOUT
      MPACFL=INOUT+15
      GO TO (705,710),INOUT
  705 CALL ENTER(16,FILNM1)
      GO TO 1
  710 CALL ENTER(17,FILNM2)
C
C     N = 1 FOR PHYSICAL DENSITY,= 2 FOR UNIT DENSITY.
C     NOFILE = 0 - CONTINUE
C              1 - STATISTICAL CALCULATIONS ARE NOT TO BE MADE FOR
C                  THIS DENSITY.
C     IPLT1 = 0 PLOT THE CUMULATIVE GRAPHS;
C           = 1 DO NOT PLOT THE GRAPHS.
C     IPLT2 = 0 PLOT THE DM/DLOGD GRAPHS;
C           = 1 DO NOT PLOT THE GRAPHS.
C     IPLT3 = 0 PLOT THE DN/DLOGD GRAPHS;
C           = 1 DO NOT PLOT THE GRAPHS.
C     IPLT4 = 0 PLOT THE CUMULATIVE PERCENT GRAPHS;
C           = 1 DO NOT PLOT THE GRAPHS.
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C      IF ISIZ1,ISIZ2,ISIZ3 - 0 PLOT ON A STANDARD GRID;
C                           - 1 PLOT ON DATA REGULATED GRID.
C      (SEE SUBROUTINE STPLOT FOR THE X AXIS AND Y AXIS GRID VALUES
C*     THAT ARE USED FOR A DATA REGULATED GRID AND STANDARD GRID.)
C      NCUCON - 1 FOR CONSTANT OF INTERGRATION AND LOWER GRID FOR AN
C                  CUMULATIVE LESS THAN .25 MICRONS;
C             - 0 CONSTANT NOT DESIRED.
C
    1 READ(2,800)N,NOFILE,IPLT1,IPLT2,IPLT3,IPLT4,ISIZ1,ISIZ2,ISIZ3,
     1NCUCON
  903 IF(NOFILE)900,900,905
  905 WRITE(MPACFL)BLAK,IBLAK
      IF(N.EQ.1)GO TO 1
      STOP
C
C      ALL STATISTICAL PLOTS WILL STOP AT 8.0 MICRONS FOR
C      CALCULATIONS USING PHYSICAL DENSITY AND AT 10.0
C      MICRONS FOR CALCULATIONS USING AERODYMANIC DENSITY.
C      THIS CAN BE CHANGED, HOWEVER BY CARD INPUT. READ IN
C       *NSTOP* NOT EQUAL TO 0 AND LARGEST DESIRED
C      DIAMETER (MICRONS) AS'STOP'
C
  900 PSTOP=8.0
      ASTOP=10.0
      READ(2,805)PEND
      IF(PEND.EQ.0.)GO TO 910
      IF(N.EQ.1)PSTOP=PEND
      IF(N.EQ.2)ASTOP=PEND
C
C      NRUN- NUMBER OF IMPACTOR RUNS. 2 RECORDS FOR EACH RUN (ONE FOR
C      PHYSICAL DENSITY DATA, ONE FOR AERODYNAMIC DENSITY DATA) STORED
C      BY MAINLINE PROGRAM MPPROG.
C      IMPAC=1- ANDERSEN IMPACTOR USED
C      IMPAC=2- BRINK IMPACTOR USED
C      IMPAC=3- UNIVERITY OF WASHINGTON MARK III IMPACTOR USED
C      IMPAC=4- MRI IMPACTOR USED
C      IDALL- GENERAL IDENTIFICATION LABEL
C      RHO1- PHYSICAL PARTICLE DENSITY (GM/CC)
C
C      THE FOLLOWING ARE MAXIMUMS AND MINIMUMS OF ALL RUNS
C      AT A GIVEN DENSITY. EACH ONE IS DIMENSIONED 2.
C      E.G.GEMAX(1)=MAXIMUM GEOM. MEAN DIAM. FOR ALL PARTICLES
C      USING DENSITY=PHYICAL DENSITY. GEMAX(2) IS THIS
C      MAXIMUM FOR ALL PARTICLES USING AERODYNAMIC
C      DENSITY=1.0 GM/CC.
C
C      GEMAX- MAXIMUM GEOMETRIC MEAN DIAMETER (MICRONS)
C      GEMIN- MINIMUM GEOMETRIC MEAN DIAMETER (MICRONS)
C      DMMAX- MAXIMUM DM/DLOGD (MG/DNM3)
C      DMMIN- MINIMUM DM/DLOGD (MG/DNM3)
C      DNMAX- MAXIMUM DNLDLOGD (NO/DNM3)
C      DNMIN- MINIMUM DNLDLOGD (NO/DNM3)
C      DPMAX- MAXIMUM PARTICLE DIAMETER (MICRONS)
C      DPMIN- MINIMUM PARTICLE DIAMETER (MICRONS)
C      CUMAX- MAXIMUM CUMULATIVE MASS LOADING (MG/ACM)
C      CUMIN- MINMUM  CUMULATIVE MASS LOADING (MG/ACM)
C
  910 READ(10'101)NRUN,IMPAC,IDALL,RHO1,GEMAX,GEMIN,DMMAX,DMMIN,DNMAX,
     1DNMIN,DPMAX,DPMIN,CUMAX,CUMIN
C
```

```
C     RHOX IS THE ASSUMED DENSITY = PHYSICAL IF N = 1, AERODYNAMIC IF
C     N = 2.
C
      RHOX=RHO1
      IF(N.EQ.2)RHOX=1.0
C
C     ISFIN--FINAL RUN INDEX NUMER
C
      ISFIN=NRUN*2
      IF(N.EQ.1)ISFIN=ISFIN-1
      ATGL(N)=0.0
C
C     THIS LOOP READS THE TOTAL MASS LOADING TGL(IS) (MG/ACM) FOR EACH
C     RUN.
C
      DO 912 IAV=N,ISFIN,2
      READ(10*IAV)IS,NFIT,TGL(IS)
  912 CONTINUE
C
C     HERE,AVCON TAKES ALL TOTAL MASS LOADING VALUES,TGL,
C     AND RETURNS THE AVERAGE TOTAL MASS LOADING FOR ALL RUNS OF THE
C     DESIGNATED DENSITY, ATGL(N), BASED ON EXCLUSION OF ANY OUTLYING
C     TGL(IS) VALUES.
C     NOCON(1) AND ALL VARIABLES AFTER ATGL(N) ARE DUMMY VARIABLES HERE.
C     SETTING IAVLD=0 INDICATES ONLY AVERAGES TO BE FOUND IN AVCON=NO
C     CONFIDENCE LIMITS.
C
      IAVLD=0
      CALL AVCON(N,IAVLD,MDK,NOCON(1),ISFIN,TGL,
     1ATGL(N),AVDM1,CUM2D(1),CUM2LD,CISUM,SIGMA,CLU(1),
     2CLL(1),DINC)
C
C     SEE COMMENTS AFTER STATEMENT 82 PRIOR TO CALL FOR
C     AVCON FOR DEFINITIONS OF THE FOLLOWING VARIABLES.
C
      CUM2LD=0.0
      CUM2D(1)=0.0
      CISUM=0.0
      AVDM1=0.0
C
C     * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C     THIS LOOP CONSTITUTES THE REMAINDER OF THE PROGRAM. VALUES FOR
C     THE FOLLOWING AVERAGES ARE FOUND FOR EACH DIAMETER ACCORDING TO
C     MDK:
C
C       MDK=1 - AVERAGE CUMULATIVE MASS LOADING < INDICATED DIAMETER
C               (CUM2D VS. DPLOT) AND ALSO AVERAGE CUMULATIVE % MASS
C               LOADING < INDICATED DIAMETER (CUM2D AFTER DIVISION BY
C               TOTAL MASS LOADING VS. DPLOT)
C       MDK=2 - AVERAGE MASS SIZE DISTRIBUTION (DM/DLOGD AS AVD VS.
C               DPLOT)
C       MDK=3 - AVERAGE NUMBER SIZE DISTRIBUTION (DN/DLOGD AS AVD VS.
C               DPLOT)
C
C     PRINT OUT AND GRAPHS (AS DESIRED) ARE MADE FOR THESE. ALSO, A
C     LIST OF RECORDS IS GIVEN WHICH PRODUCED OUTLYING VALUES NOT
C     INCLUDED IN AVERAGE
C     INCLUDED IN AVERAGING AT EACH DIAMETER.
C     * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C
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      DO 254 MDK=1,3
C
C     NDK "PARALLELS MDK, USED INSTEAD OF MDK FOR LOGICAL "IF"
C     STATEMENTS.
C     NDK1=0--THIS IS ALWAYS TRUE EXCEPT WHEN FINDING
C     AVG. PERCENT CUMULATIVE MASS LOADING WHERE NDK1 = 1.
C
      NDK=MDK-2
      NDK1=0
      GO TO (922,915,13),MDK
C     WRITE GENERAL HEADING FOR CUM. MASS LOADING OUTPUT.
C     INCLUDES GENERAL ID, DENSITY, COLUMN HEADINGS FOR
C     'SLOT',DIAMETER (MICRONS), MEAN CUMULATIVE MASS CONCENTRATION
C     (MG/ACM), UPPER CONFIDENCE LIMIT (MG/ACM), AND LOWER CONFIDENCE
C     LIMIT (MG/ACM).
C
  922 WRITE(3,700)IDALL,RHOX
C
C     IPLT1=0 - STPLOT IS CALLED TO DRAW GRID FOR CUM. MASS LOADING <
C     PARTICLE DIAMETER.
C
C     IF ISIZ1=1 FIND MAX (XMAX) AND MIN. (XMIN) X VALUES OF GRID
C     GIVEN DPMAX AND DPMIN RESPECTIVELY. IF ISIZ1=1 FIND MAX. (YMAX)
C     AND MIN. (YMIN) Y VALUES OF GRID GIVEN CUMAX AND CUMIN
C     RESPECTIVLY. IF ISIZ=0, THESE WILL HAVE PRE-SET VALUES.
C
      IF(IPLT1)2,2,32
    2 ISIZ=ISIZ1
C
C     FIND THE X AND Y SCALE FACTORS, XS AND YS, RESPECTIVLY
C     (INCHES/USER'S UNIT). DRAW GRID FOR AVG. CUMULATIVE MASS LOADING
C     VS. PARTICLE DIAMETER AND LABEL WITH GENERAL IDENTIFICATION IDALL
C     AND DENSITY RHOX(GM/CC).
C
      CALL STPLOT(IDALL,RHOX,IMPAC,NDK,DPMAX,DPMIN,CUMAX,CUMIN,ISIZ,
     1XS,YS,XMAX,XMIN,YMAX,YMIN)
      GO TO 32
C
C     WRITE GENERAL HEADING FOR DM/DLOGD OUTPUT. INCLUDES GENERAL
C     ID,DENSITY,COLUMN HEADINGS FOR 'SLOT',DIAMETER (MICRONS),
C     MEAN CHANGE IN MASS CONCENTRATION (MG/DNM3), STANDARD
C     DEVIATION (MG/DNM3), UPPER CONFIDENCE LIMIT (MG/DNM3),
C     AND LOWER CONFIDENCE LIMIT (MG/DNM3).
C
  915 WRITE(3,500)IDALL,RHOX
C
C     IF IPLT2=0-STPLOT WILL BE CALLED. AGAIN,STPLOT FINDS
C     MAX. AND MIN. VALUES FOR GRID THIS TIME USING GEMAX,
C     GEMIN,DMMAX,AND DMMIN IF ISIZ2=1. USES PRE-SET VALUES
C     FOR ISIZ2=0. SCALE FACTORS XS AND YS ARE CALCULATED.
C     GRID IS DRAWN FOR AVG. DM/DLOGD VS. GEOMETRIC MEAN
C     DIAMETER.
C
      IF(IPLT2)3,3,32
    3 ISIZ=ISIZ2
      CALL STPLOT(IDALL,RHOX,IMPAC,NDK,GEMAX,GEMIN,DMMAX,DMMIN,
     1ISIZ,XS,YS,XMAX,XMIN,YMAX,YMIN)
      GO TO 32
C
C     AS ABOVE FOR DN/DLOGD PLOT.
```

```
C
   13 WRITE(3,600)IDALL,RHOX
      IF(IPLT3)6,6,32
    6 ISIZ=ISIZ3
      CALL STPLOT(IDALL,RHOX,IMPAC,NDK,GEMAX,GEMIN,DNMAX,DNMIN,
     1ISIZ,XS,YS,XMAX,XMIN,YMAX,YMIN)
C
C     THE INTERVAL LENGTH DINC IS DEFINED SUCH THAT THERE ARE 28
C     INTERVALS PER LOG10 CYCLE FOR CALCULATION OF AVG. CUM. MASS
C     LOADING AND 14 INTERVALS PER LOG10 CYCLE FOR CALCULATION OF
C     DM/DLOGD AND DN/DLOGD CALCULATIONS.
C
   32 IF(NDK)133,134,134
  133 DINC=.0357142857
      GO TO 135
  134 DINC=.0714285714
C
C     THE FIRST DIAMETER TAKEN FOR CALCULATION IS AT
C     .25 MICROMETERS. THE VARIABLE USED FOR FITTING IS
C     D1 = LOG10(DIAMETER) AND RESULT IS LOG10(CUM. MASS LOADING).
C
  135 D1=ALOG10(.25)
C
C     THE DIAMETER AT WHICH PLOTTING WILL END (PSTOP OR
C     ASTOP DEPENDING ON DENSITY) GOES THROUGH CHANGE OF
C     VARIABLE AND INITIAL DIAMETER VARIABLE SUBTRACTED
C     FROM IT. DIVIDING INTERVAL LENGTH (DINC) INTO THIS GIVES
C     TOTAL NUMBER OF INTERVALS (PLAS) IN
C     WHICH THERE WILL BE A CALCULATION. THIS REAL NUMBER
C     IS ROUNDED TO NEXT HIGHER INTEGER (LAS)
C
      DSTOP=PSTOP
      IF(N.EQ.2)DSTOP=ASTOP
      PLAS=(ALOG10(DSTOP)-D1)/DINC
      LAS=PLAS+1.0
C
C     WHEN CALCULATIONS OF AVG. DM/DLOGD ARE BEING MADE, THE FOLLOWING
C     VALUES ARE WRITTEN ON FILE MPACFL FOR USE IN PROGRAM PENTRA.
C
      IF(NDK.EQ.0)WRITE(MPACFL)RHOX,LAS
C
C     THE FOLLOWING LOOP CONTAINS ALL CALCULATIONS TO
C     GET AVG. CUM. MASS LOADING (WHEN NDK = -1), AVG.
C     DM/DLOGD (WHEN NDK=0), AND AVG. DN/DLOGD (WHEN
C     NDK=1) VS. PARTICLE DIAMETER. BOTH PLOTTING AND
C     LINE PRINTING OUTPUT ARE MADE HERE. NOTE: AVG.
C     PERCENT CUM. MASS LOADING VS. DIAMETER IS DONE
C     OUTSIDE THIS LOOP BEGINNING AT 255.
C
      DO 200 NSLOT=1,LAS
      MSLOT=NSLOT-1
C
C     D1--FITTING VARIABLE, FUNCTION OF DIAMETER
C     DPLOT--DIAMETER (MICRONS)
C
      DPLOT=10.0**D1
C
C     NUPTS--NUMBER OF CHANGES ADDED TO GET SUM.
C     SUM--SUM OF CHANGES: NDK=-1--DM/DLOGD(MG/ACM)
C                          NDK= 0--DM/DLOGD(MG/DNM3)
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C                           NDK= 1--DN/DLOGD(NO./DNM3)
C
      NUPTS=0
      SUM=0.0
      DO 75 IAV=N,ISFIN,2
C
C     READ RECORD OF EACH RUN TO GET TEMPERATURE OF
C     STACK IN DEG. KELVIN (TKS), PRESSURE AT IMPACTOR
C     INLET IN ATMOSPHERE (POA), PERCENT WATER CONTENT
C     OF GAS (FGH2O).
C
      READ(10'IAV)IS,NFIT,GRNAM,ID,RHO,TKS,POA,FGH2O
C
C     READ THE NUMBER OF FITTED POINTS NPOIN. THE VALUES OF THE POINTS
C     USED FOR FITTING X1(I),I=1,NPOIN AND Y1(I),I=1,NPOIN, AND
C     THE VALUES OF THE FITTING COEFFICIENTS COE(I,J),I=1,NO. OF INTERVALS
C     AND J=1,3.
C
      READ(11'IS)NPOIN
      INT=NPOIN-1
      READ(11'IS)NPOIN,(X1(I),I=1,NPOIN),(Y1(I),I=1,NPOIN),
     1((COE(I,J),J=1,3),I=1,INT)
C
C     DETERMINE WHICH INTERVAL OF CURVE FIT NINT FOR THE DIAMETER
C     VARIABLE D1.
C
      DO 128 I=2,NPOIN
      J=I
      IF(D1.LT.X1(I))GO TO 132
  128 CONTINUE
  132 NINT=J-1
C
C     FOR THE FIRST DIAMETER (NSLOT = 1) IN AVG. CUMULATIVE MASS
C     LOADING CALCULATIONS (NDK = -1), AN INTEGERATION CONSTANT (AN
C     INITIAL VALUE OF CUMULATIVE MASS LOADING < THE DIAMETER "PREVIOUS"
C     TO .25 MICROMETERS), CUCON1(IS), IS CALCULATED FOR EACH RUN IF
C     DESIRED (NCUCON INPUT = 0).
C
      IF(NSLOT.NE.1.OR.NDK.NE.-1)GO TO 1133
      IF(NCUCON) 1133,1132,1133
 1132 CUCON1(IS)=COE(NINT,1)+COE(NINT,2)*(D1-DINC)+COE(NINT,3)*
     1(D1-DINC)**2
      IF (CUCON1(IS).LE.-5.0)CUCON1(IS)=-5.0
      CUCON1(IS)=10.0**CUCON1(IS)
C
C     CALCULATE THE DERIVATIVE OF THE MASS CONCENTRATION, DELMBC.
C     THE FIRST CALCULATION OF DELMBC HERE IS DERIVATIVE OF LOG10(MASS
C     CONCENTRATION) WITH RESPECT TO LOG10(DIAMETER). USING THIS,
C     REDEFINE DELMBC AS DERIVATIVE OF MASS CONCENTRATION WITH RESPECT
C     TO LOG10(DIAMETER). PPP IS THE LOG10(MASS CONCENTRATION)
C     CALCULATED FROM THE CURVE FITTING POLYNOMIAL FOUND IN MAINLINE
C     PROGRAM SPLIN1.
C
 1133 DELMBC=COE(NINT,2)+COE(NINT,3)*2*D1
      PPP=COE(NINT,1)
      DO 131 L=2,3
  131 PPP=PPP+COE(NINT,L)*D1**(L-1)
      DELMBC=DELMBC*(10.0**PPP)*2.302585
C
C     CONVRT IS THE CONVERSION FACTOR TO GO FROM MG/ACM TO MG/DNM3
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C     THEREFORE:DELMBC=HAS UNITS MG/ACM
C                 DELM---HAS UNITS MG/DNM3
C                 DELN---HAS UNITS NO./DNM3
C
      CONVRT=(((294.0*POA)/TKS*1.0)*((100.0-FGH20)/100.0))
      DELM=DELMBC/CONVRT
      DELN=((6.0*DELM)/(RHOX*3.141592*DPLOT**3.))*1.0E09
      IF(NDK)451,51,52
  451 DEL(IS)=DELMBC
      GO TO 75
   51 DEL(IS)=DELM
      GO TO 75
   52 DEL(IS)=DELN
   75 CONTINUE
   80 CONTINUE
      IAVLD=1
C
C     FOR THE FIRST DIAMETER (NSLOT = 1) IN AVG. CUMULATIVE MASS
C     LOADING CALCULATIONS (NDK = -1), AN AVERAGE INTEGRATION CONSTANT
C     (THE AVERAGE INITIAL VALUE OF CUMULATIVE MASS LOADING < .25 MICRO-
C     METERS), CUCON(N), IS CALCULATED FOR THIS ASSUMED DENSITY IF
C     DESIRED (NCUCON INPUT = 0).
C
      IF(NSLOT.NE.1.OR.NDK.NE.-1) GO TO 82
      IF(NCUCON) 82,81,82
   81 CALL AVCON (N,IAVLD,NDK,NOCON(NSLOT),ISFIN,CUCON1,CUCON(N),AVDM1,
     1CUM2D(NSLOT),CUM2LD,CISUM,SIGMA,CLU(NSLOT),CLL(NSLOT),DINC)
      CUM2LD=CUCON(N)
   82 NOCON(NSLOT)=0
      AVD=0.0
C
C     AVCON USES THE FOLLOWING VARIABLES:
C          N - AS DESCRIBED PREVIOUSLY
C          IAVLD = 1 - FIND 90 PERCENT CONFIDENCE INTERVALS PROVIDED
C                      THERE IS SUFFICIENT DATA.
C          IAVLD = 0 - CONFIDENCE INTERVALS NOT DESIRED.
C          NDK - AS DESCRIBED PREVIOUSLY
C          NOCON(NSLOT) - INDICATES, UPON RETURN FROM SUBROUTINE AVCON,
C                         WHETHER OR NOT CONFIDENCE LIMITS WERE TAKEN.
C                         THERE MUST BE AT LEAST 3 PIECES OF DATA FOR THESE
C                         CALCULATIONS. NOCON(NSLOT) RETURNED = 1
C                         IF THERE WAS INSUFFICIENT DATA
C                         AND NO CONFIDENCE LIMITS WERE TAKEN.
C          ISFIN - AS DESCRIBED PREVIOUSLY
C          DEL - SET OF ALL CHANGES PER CHANGE IN LOG10 DIAMETER AT
C                THE INDICATED DIAMETER. (ACTUALLY THESE ARE THE DERIVATIVE
C                LIMITS OF THE CHANGES.)
C          AVD - PRELIMINARY AVERAGE OF THESE CHANGES.
C          SIGMA - STANDARD DEVIATION OF THE SET DEL.
C          CLU(NSLOT) - UPPER 90 PERCENT CONFIDENCE LIMIT OF DEL AT
C                       THE INDICATED DIAMETER.
C          CLL(NSLOT) - LOWER 90 PERCENT CONFIDENCE LIMIT OF THE SET DEL
C                       AT THE INDICATED DIAMETER.
C     FOR NDK = -1 AVCON WILL ALSO USE THE FOLLOWING VARIABLES:
C          AVDM1 - AVERAGE OF CHANGES AT PREVIOUS DIAMETER
C          CUM2D(NSLOT) - AVERAGE CUMULATIVE MASS LOAD OF PARTICLES SMALLER
C                         THAN INDICATED DIAMETER (MG/ACM).
C          CUM2LD - AVERAGE CUMULATIVE MASS LOAD FOR PARTICLES SMALLER
C                   THAN LAST DIAMETER (MG/ACM)
C          CISUM - THE SUM OF THE SQUARES OF THE DM/DLOGD CONFIDENCE
```

```
C                 INTERVALS (MG/ACM) FOR PARTICLES SMALLER THAN THE
C                 LAST DIAMETER.
C           DINC - LOG10 DIAMETER INCREMENT (MICRONS).
C
      CALL AVCON(N,IAVLD,NDK,NOCON(NSLOT),ISFIN,DEL,
     1AVD,AVDM1,CUM2D(NSLOT),CUM2LD,CISUM,SIGMA,CLU(NSLOT),
     2CLL(NSLOT),DINC)
      NSETS=NOCON(NSLOT)+1
C
C     IF NOCON(NSLOT) IS RETURNED = 1, A SPECIAL FORMAT IS USED FOR
C     PRINT OUT NOTING 'INSUFFICIENT DATA' (THIS IS FORMAT
C     503 FOR AVG. CUM. MASS LOAD. AND FORMAT 501 FOR AVG. DM/DLOGD
C     OR AVG. DN/DLOGD). OTHERWISE, AVG. CUM. MASS LOADING
C     CALCULATIONS GIVE OUTPUT ACCORDING TO FORMAT 504 LISTING
C     THE 'SLOT', PARTICLE DIAMETER (DPLOT IN MICRONS), AVG. CUM.
C     MASS LOADING (CUM2D IN MG/ACM), UPPER 90 PERCENT CINFIDENCE
C     LIMIT, AND LOWER 90 PERCENT CONFIDENCE LIMIT (CLU AND CLL
C     RESPECTIVLY IN MG/ACM). A SIMILAR OUT=PUT FOR AVG. DM/DLOGD
C     AND AVG. DN/DLOGD CALCULATION IS LISTED USING FORMAT 502.
C     DIAMETER UNITS ARE AGAIN, MICRONS. OTHER VARIABLES ARE IN
C     MG/DNM3 (DM/DLOGD CALCULATIONS) OR NO/DNM3 (DN/DLOGD
C     CALCULATIONS). NOTE ALSO THAT THE STANDARD DEVIATION, SIGMA,
C     IS LISTED FOR THE DM/DLOGD AND DN/DLOGD CALCULATIONS.
C
      GO TO (85,90),NSETS
   85 IF(NDK)87,97,98
   90 IF(NDK)86,96,96
   86 WRITE(3,503)NSLOT,DPLOT,CUM2D(NSLOT)
      GO TO 110
   96 WRITE(3,501)NSLOT,DPLOT,AVD
      GO TO 110
   87 WRITE(3,504)NSLOT,DPLOT,CUM2D(NSLOT),CLU(NSLOT),CLL(NSLOT)
      GO TO 110
   97 WRITE(3,502)NSLOT,DPLOT,AVD,SIGMA,CLU(NSLOT),CLL(NSLOT)
      GO TO 110
   98 WRITE(3,505)NSLOT,DPLOT,AVD,SIGMA,CLU(NSLOT),CLL(NSLOT)
  110 NOUT(NSLOT)=0
      NIN=0
      DO 116 IAV=N,ISFIN,2
      IF(DEL(IAV))113,115,115
  113 NOUT(NSLOT)=NOUT(NSLOT)+1
      NT=NOUT(NSLOT)
      THROUT(NSLOT,NT)=IAV
      GO TO 116
  115 NIN=NIN+1
  116 CONTINUE
      IF(NDK)117,118,119
  117 IF(IPLT1)1117,1117,2118
 1117 IPLOT=(-1)**NSLOT
      IF(IPLOT)2117,2117,2118
 2117 CALL STATPT(NDK1,NOCON(NSLOT),DPLOT,CUM2D(NSLOT),CLU(NSLOT),
     1CLL(NSLOT),XMAX,XMIN,YMAX,YMIN,XS,YS)
 2118 AVDM1=AVD
      CUM2LD=CUM2D(NSLOT)
      GO TO 150
  118 WRITE(MPACFL)DPLOT,AVD,SIGMA,NIN
      IF(IPLT2)140,140,150
  119 IF(IPLT3)140,140,150
  140 CALL STATPT(NDK1,NOCON(NSLOT),DPLOT,AVD,CLU(NSLOT),CLL(NSLOT),
     1XMAX,XMIN,YMAX,YMIN,XS,YS)
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150  D1=D1+DINC
 200 CONTINUE
     WRITE(3,702)IDALL,RHOX
     IF(NDK)202,203,204
 202 WRITE(3,704)
     GO TO 205
 203 WRITE(3,706)
     GO TO 205
 204 WRITE(3,708)
 205 D1=ALOG10(.25)
     DO 221 NSLOT=1,LAS
     DPLOT=10.0**D1
     NT=NOUT(NSLOT)
     IF(NT)207,207,211
 207 WRITE(3,711)NSLOT,DPLOT
     GO TO 220
 211 WRITE(3,712)NSLOT,DPLOT,(THROUT(NSLOT,I),I=1,NT)
 220 D1=D1+DINC
 221 CONTINUE
C
C     IF NDK = -1, CHECK TO SEE IF PLOT WAS MADE (SO THAT PEN CAN BE
C     READIED FOR NEXT PLOT.)
C     IF NDK = 0 WRITE 5 ASTERISKS (DAST) IN FILE MPACFL. THIS
C     WILL BE AND INDICATION IN PROGRAM PENTRA THAT SET OF
C     RECORDS ALL HAVING SAME DENSITY HAS BEEN REACHED.
C     IF NDK =  1, CHECK TO SEE IF PLOT WAS MADE (SO THAT PEN CAN BE
C     READIED FOR NEXT PLOT.)
C
      IF(NDK)255,251,252
C
C     IF PLOT WAS MADE, READY PEN FOR NEXT PLOT. IF PLOT WAS NOT MADE,
C     MAKE CALCULATIONS FOR AVERAGE CUMULATIVE PERCENT.
C
 255 IF(IPLT1)304,304,253
C
C
C     STATEMENTS 253 THROUGH 270 MAKE CALCULATIONS AND GIVE OUTPUT
C     FOR AVERAGE CUMULATIVE PERCENT.
C
C     THIS STATEMENT WRITES THE GENERAL IDENTIFICATION LABEL
C     IDALL, THE DENSITY, RHOX IN GM/CC, AND THE COLUMN HEADINGS
C     WHICH INCLUDE 'INTERVAL' 'DIAMETER (MICRONS)','MEAN CUMULATIVE
C     MASS CONCENTRATION (PERCENT)' 'UPPER CONFIDENCE LIMIT (PERCENT)',
C     AND 'LOWER CONFIDENCE LIMIT (PERCENT)'
C
 253 WRITE(3,701)IDALL,RHOX
     IF(IPLT4)257,257,258
C
C     SUBROUTINE CPPLOT TAKES AS VARIABLES THE GENERAL ID,IDALL,
C     AND THE DENSITY RHOX. IT DRAWS THE GRID FOR AVG. CUM. PERCENT
C     MASS LOADING, LABELS THE AXES, AND WRITES A GENERAL HEADING
C     CONSISTING OF IDALL AND RHOX. THE MAXIMUMAND MINIMUM VALUES
C     ALONG EACH AXIS-XMAX,XMIN,YMAX,AND YMINALONG WITH THE SCALE
C     FACTORS-XS AND YS- ARE RETURNED.
C
 257 CALL CPPLOT(IDALL,RHOX,XMAX,XMIN,YMAX,YMIN,XS,YS)
C
C     D1 = ALOG10 DIAMETER
C
 258 D1=ALOG10(.25)
```

```
      NDK1=1
C
C     NOTE - PLOT BEGINS WITH SAME D1 AS IN AVERAGE CUMULATIVE MASS PLOT.
C     ALSO, NUMBER OF POINTS, LAS, IS THE SAME ONLY EVERY OTHER POINT
C     IS PLOTTED I.E. WHEN IPLOT = -1.
C
      DO 270 NSLOT=1,LAS
C
C     DPLOT = DIAMETER
C
      DPLOT=10.0**D1
C
C     AVG. CUM. MASS LOAD, UPPER CONFIDENCE LIMIT, AND LOWER
C     CONFIDENCE LIMIT ARE CHANGED TO FRACTIONS OF THE AVG. TOTAL
C     MASS LOADING. (ONLY AVG. CUM. MASS LOAD. MAKES THIS CHANGE
C     OF VARIABLE IF NOT ENOUGH DATA FOR CONFIDENCE LIMITS IE.
C     NOCON = 1.)
C
      CUM2D(NSLOT)=CUM2D(NSLOT)/ATGL(N)
      CLU(NSLOT)=CLU(NSLOT)/ATGL(N)
      CLL(NSLOT)=CLL(NSLOT)/ATGL(N)
      IPLOT=(-1)**NSLOT
      IF(IPLT4.EQ.1.OR.IPLOT.NE.-1)GO TO 260
C
C     SUBROUTINE STATPT TAKES SAME VARIABLES AS IN STATEMENT 1100
C     BUT WITH NDK1=1, POINT IS PLOTTED ACCORDING TO LOG NORMAL
C     PROBABILITY SCALE RATHER THAN LOG10 SCALE.
C
      CALL STATPT(NDK1,NOCON(NSLOT),D1,CUM2D(NSLOT),CLU(NSLOT),
     1CLL(NSLOT),XMAX,XMIN,YMAX,YMIN,XS,YS)
C
C     VARIABLES ARE CHANGED FROM FRACTION TO PERCENT FOR LINE
C     PRINTER OUTPUT.
C
  260 CUM2D(NSLOT)=CUM2D(NSLOT)*100.0
      CLU(NSLOT)=CLU(NSLOT)*100.0
      CLL(NSLOT)=CLL(NSLOT)*100.0
C
C     THIS WRITE STATEMENT USES FORMAT 504 TO PRINT OUT THE
C     INTERVAL NSLOT, THE DIAMETER DPLOT IN MICRONS, THE
C     MEAN CUM. MASS LOAD CUM2D (NSLOT), UPPER 90 PERCENT
C     CONFIDENCE LIMIT CLU (NSLOT) AND LOWER 90 PERCENT CONFIDENCE
C     LIMIT CLL(NSLOT) ALL IN PERCENT.
C
      IF(NOCON(NSLOT).EQ.1)GO TO 261
      WRITE(3,504)NSLOT,DPLOT,CUM2D(NSLOT),CLU(NSLOT),CLL(NSLOT)
      GO TO 265
C
C     IF THERE IS NOT ENOUGH DATA AT THIS DIAMETER FOR CONFIDENCE
C     LIMITS, ONLY THE INTERVAL, DIAMETER, AND AVG. ARE PRINTED
C     WITH 'INSUFFICIENT DATA' PRINTED FOR BOTH CONFIDENCE LIMITS
C     USING FROMAT 503
C
  261 WRITE(3,503)NSLOT,DPLOT,CUM2D(NSLOT)
C
C     THE DIAMETER IS INCREMENTED AND LOOP RETURNS FOR CALCULATIONS
C     AT THIS NEW POINT.
C
  265 D1=D1+DINC
  270 CONTINUE
```

```
C
C     IF PLOT WAS MADE, READY PEN FOR NEXT PLOT. IF PLOT WAS NOT MADE,
C     INCREMENT NDK AND RETURN TO STATEMENT 915 FOR CALCULATIONS OF
C     AVERAGE DM/DLOGD.
C
      IF(IPLT4)304,304,254
  251 WRITE(MPACFL)DAST,DAST,DAST,IBLAK
C
C     IF PLOT WAS MADE, READY PEN FOR NEXT PLOT. IF PLOT WAS NOT MADE,
C     INCREMENT NDK AND RETURN TO STATEMENT 13 FOR CALCULATIONS OF
C     AVERAGE DN/DLOGD.
C
      IF(IPLT2)304,304,254
C
C     IF PLOT WAS MADE READY PEN FOR NEXT PLOT. IF PLOT WAS NOT MADE,
C     INCREMENT NDK AND RETURN TO STATEMENT 1 FOR REPEAT OF ALL
C     CALCULATIONS USING THE AERODYNAMIC DENSITY.
C
  252 IF(IPLT3)304,304,254
  304 XN=XMAX+4.5/XS
      YN=YMIN-2./YS
      CALL FPLOT(0,XN,YN)
      IF(NDK.EQ.-1.AND.NDK1.EQ.0)GO TO 253
  254 CONTINUE
      IF(N.EQ.1)GO TO 1
 1000 STOP
  500 FORMAT(1H1,//,1X,80A1/,1X,'RHO= ',F4.2.' GM/CC'/,
     &                                     28X,'MEAN CHANGE',8X,'STAN
     1DARD   UPPER CONFIDENCE   LOWER CONFIDENCE'/,1X,'INTERVAL   DIAMET
     2ER   IN MASS CONCENTRATION   DEVIATION',7X,'LIMIT',14X,'LIMIT'/,2
     39X,'(MG/DNM3)',9X,'(MG/DNM3)',5X,2('(MG/DNM3)',10X))
  501 FORMAT(4X,I2,5X,2(1PE9.2,10X),6X,'------- INSUFFICIENT DATA ------
     1-')
  502 FORMAT(4X,I2,5X,2(1PE9.2,9X),2(1PE9.2,5X),5X,1PE9.2)
  503 FORMAT(4X,I2,5X,1PE9.2.7X,1PE9.2,10X,'---- INSUFFICIENT DATA ----'
     1)
  504 FORMAT(4X,I2,5X,1PE9.2,7X,1PE9.2,9X,1PE9.2.10X,1PE9.2)
  505 FORMAT(4X,I2,5X,2(1PE9.2,10X),2(1PE9.2.5X),5X,1PE9.2)
  600 FORMAT(1H1,//,1X,80A1/,1X,'RHO= ',F4.2.' GM/CC'/,
     &                                     29X,'MEAN CHANGE',9X,'STAN
     1DARD   UPPER CONFIDENCE   LOWER CONFIDENCE'/,1X,'INTERVAL   DIAMET
     2ER   IN NUMBER CONCENTRATION   DEVIATION',7X,'LIMIT',14X,'LIMIT'/,
     330X,'(NO/DNM3)',10X,2('(NO/DNM3)',5X),5X,'(NO/DNM3)')
  700 FORMAT(1H1,//,1X,80A1/,1X,'RHO= ',F4.2.' GM/CC'/,
     &                                     24X,'MEAN CUMULATIVE   UPP
     1ER CONFIDENCE   LOWER CONFIDENCE'/,1X,'INTERVAL   DIAMETER   MASS
     2CONCENTRATION',6X,'LIMIT',14X,'LIMIT'/.12X,'(MICRONS)',7X,'(MG/ACM
     33)',10X,'(MG/ACM)',11X,'(MG/ACM)'/)
  701 FORMAT(1H1,//,1X,80A1/,1X,'RHO= ',F4.2.' GM/CC'/,
     &                                     24X,'MEAN CUMULATIVE   UPP
     1ER CONFIDENCE   LOWER CONFIDENCE'/,1X,'INTERVAL   DIAMETER   MASS
     2CONCENTRATION      LIMIT',14X,'LIMIT'/.12X,'(MICRONS)',6X,'(PERCEN
     3T)',9X,2('(PERCENT)',10X))
  702 FORMAT(1H1,//,1X,80A1/,1X,'RHO= ',F4.2.' GM/CC'/,
     &                                     1X,'INTERVAL',3X,'DIAMETER
     1',4X,'RECORDS EXCLUDED FROM MEAN')
  704 FORMAT(23X,'CUMULATIVE MASS CONCENTRATION'/)
  706 FORMAT(23X,'CHANGE IN MASS CONTRATION'/)
  708 FORMAT(22X,'CHANGE IN NUMBER CONCENTRATION'/)
  711 FORMAT(4X,I2.5X,1PE9.2,6X,'NONE')
```

```
712 FORMAT(4X,I2,5X,1PE9.2,5X,25(1X,I2))
800 FORMAT(10(I1))
805 FORMAT(F5.1)
    END
```

```
      SUBROUTINE AVCON(N,IAVLD,NDK,NOCON,ISFIN,VAR,AVG,
     1AVGM1,CUM2D,CUM2LD,CISUM,SIGMA,CLU,CLL.DINC)
C***********************************************************************
C*
C*    SUBROUTINE AVCON TAKES A LIST OF VARIABLES VAR AND FINDS THEIR
C*    AVERAGE AVG. IT CALCULATES THE STANDARD DEVIATION
C*    OF THE VARIABLES SIGMA, CALCULATES A NEW AVERAGE AVG
C*    BY EXCLUDING ANY OUTLYING DATA. A NEW STANDARD DEVIATION SIGMA
C*    IS CALCULATED BASED ON THE NEW AVERAGE AND THE REMAINING DATA.
C*         USE THIS PROGRAM FOR 50 % CONFIDENCE LIMITS
C*
C***********************************************************************
C
      DIMENSION VAR(50)
      SUM=0.0
      NUPTS=0
      SIGMA=0.0
      DO 50 I=N,ISFIN,2
      IF(VAR(I))50,40,40
   40 SUM=SUM+VAR(I)
      NUPTS=NUPTS+1
   50 CONTINUE
      IF(NUPTS-3)190,65,65
   65 AVG=SUM/NUPTS
      LL=1
  120 SIGPA=0.0
      NUPTS=0
C
C     THIS LOOP CALCULATES SUM OF THE SQUARES OF THE DEVIATION
C     FROM THE AVERAGE.
C
      DO 125 I=N,ISFIN,2
      IF(VAR(I))125,122,122
  122 SIGPA=SIGPA+((VAR(I)-AVG)**2)
      NUPTS=NUPTS+1
  125 CONTINUE
C
C     STANDARD DEVIATION SIGMA IS CALCULATED AS SQUARE ROOT
C     OF PREVIOUS SUM DIVIDED BY 1 LESS THAN NUMBER OF VALUES SUMED.
C
      REAL=NUPTS-1
      SIGMA=SQRT(SIGPA/REAL)
C
C     SUBROUTINE CHECKS FOR CONFIDENCE LIMITS IF AVG AND SIGMA HAVE
C     BEEN CALCULATED THE SECOND TIME.
C
C
      RNPTS=NUPTS
      IF(RNPTS-7)205,210,215
  205 IF (RNPTS-3)206,206,207
  206 TCRIT=1.153
      GO TO 220
  207 TCRIT=0.102705+2.22946*ALOG10(RNPTS)
      GO TO 220
  210 TCRIT=1.938
      GO TO 220
  215 TCRIT=0.86552+1.308037*ALOG10(RNPTS)
  220 SUM=0.0
      NUPTS=0
      DO 140 I=N,ISFIN,2
      T=ABS((VAR(I)-AVG)/SIGMA)
C
C     ANY VALUE OUTSIDE OF THE ALLOWED DEVIATION FROM AVERAGE IS 'TAGGED'
C     BY SETTING IT EQUAL TO THE ARBITRARY VALUE -50.0. THESE VALUES ARE
C     NOT INCLUDED IN SECOND CALCULATION OF AVG AND SIGMA.
C
      IF(T-TCRIT)137,135,135
  135 VAR(I)=-50.0
  137 IF(VAR(I))140,138,138
  138 SUM=SUM+VAR(I)
      NUPTS=NUPTS+1
  140 CONTINUE
      IF(LL-2)146,190,190
  146 IF(NUPTS-3)190,148,148
  148 AVG=SUM/NUPTS
      LL=LL+1
C
C     SUBROUTINE RETURNS TO STATEMENT 120 FOR SECOND CALCULATION OF SIGMA
C     BASED ON NEW AVG AND EXCLUSION OF 'EXTREME' DATA.
C
      GO TO 120
C
  190 SUM=0.0
      NUPTS=0
      AVG=0.0
C
C     SUM VALUES AND SUM NUMBER OF VALUES TO CALCULATE NEW AVERAGE
C     WITHOUT "EXTREME" DATA.
C
      DO 192 I=N,ISFIN,2
      IF(VAR(I))192,191,191
  191 SUM=SUM+VAR(I)
      NUPTS=NUPTS+1
  192 CONTINUE
C
C     TAKE AVERAGE.
C
      IF(NUPTS.GE.1)AVG=SUM/NUPTS
      SIGMA=0.0
C
C     IF MORE THAN 1 'GOOD' VALUES, FIND NEW STANDARD DEVIATION AND
C     CONFIDENCE LIMITS (GO TO 1195). IF NOT, RETURN NOCON = 1.
C
      IF(NUPTS.GT.1.AND.IAVLD.EQ.1)GO TO 1195
      NOCON=1
C
C     KEEP RUNNING SUM OF CHANGES IN MASS LOADING UP TO THIS DIAMETER
C     IF NDK = -1.
C
      IF(NDK)1191,1194,1194
 1191 IF(AVG*AVGM1)1192,1192.1193
 1192 CUM2D=CUM2LD
      GO TO 1194
 1193 CUM2D=CUM2LD+SQRT(AVG*AVGM1)*DINC
 1194 CLU=0.0
      CLL=0.0
      RETURN
C
C     FIND NEW STANDARD DEVIATION AND CONFIDENCE INTERVAL.
```

```
C
 1195 DO 195 I=N,ISFIN,2
      IF(VAR(I))195,194,194
  194 SIGMA=SIGMA+((AVG-VAR(I))**2)
  195 CONTINUE
      REAL=NUPTS-1
      SIGMA=SQRT(SIGMA/REAL)
      REAL=NUPTS
      CONIN=(SIGMA*(0.674+(0.32*((REAL-1.0)**(-1.072)))))/SQRT(REAL)
C
C     NDK = -1 - CONFIDENCE LIMITS ARE FOUND FOR AVG. CUMULATIVE
C     MASS LOADING. THIS AVERAGE IS DENOTED AS CUM2D (TO BE
C     DISTINGUISHED FROM AVG). CUM2D IS FOUND BY ADDING THE AVERAGE
C     CHANGES IN MASS LOADING OVER A LOG10 DIAMETER INCREMENT,DINC, UP TO TH
C     SPECIFIED DIAMETER. THE CUMULATIVE MASS LOADING UPPER AND LOWER
C     50 PERCENT CONFIDENCE LIMITS ARE FOUND BY ADDING AND SUBTRACTING,
C     RESPECTIVELY, THE ROOT MEAN SQUARE OF ALL DM/DLOGD CONFIDENCE
C     INTERVALS UP TO AND INCLUDING THAT INTERVAL AT THE SPECIFIED
C     DIAMETER.
C
C     NDK =  0 - CONFIDENCE LIMITS ARE FOUND FOR AVG. DM/DLOGD. THESE
C     UPPER AND LOWER 50 PERCENT LIMITS ARE FOUND BY ADDING AND SUBTRACTING,
C     RESPECTIVELY, THE CONFIDENCE INTERVAL CONIN TO THE AVERAGE
C     DM/DLOGD VALUE AT THAT DIAMETER, AVD.
C
C     NDK =  1 - CONFIDENCE LIMITS ARE FOUND FOR AVG. DN/DLOGD IN
C     THE SAME MANNER AS FOR AVG. DM/DLOGD.
C
      IF(NDK)150,160,160
  150 IF(AVG*AVGM1)152,152,153
  152 CUM2D=CUM2LD
      GO TO 155
  153 CUM2D=CUM2LD+SQRT(AVG*AVGM1)*DINC
  155 CISUM=CISUM+(CONIN**2.0)
      CLU=CUM2D+(SQRT(CISUM)*DINC)
      CLL=CUM2D-(SQRT(CISUM)*DINC)
      RETURN
  160 CLU=AVG+CONIN
      CLL=AVG-CONIN
      RETURN
      END
      BLOCK DATA
      REAL MU
      COMMON/BLOCK1/PB(8),MU,POA,DPA,TCI,FG(5),DELP(8,4)
      DATA DELP/0.0,0.0,0.0,0.0,0.0,.176,.294,1.0,
     10.000,.004,.008,.014,.045,.143,1.000,0.000,
     20.000,0.000,0.000,0.000,0.057,0.566,1.000,0.000,
     30.0,0.0,0.0,0.0,0.045,0.216,1.000,0.000/
      END
      BLOCK DATA
      INTEGER X(8,4)
      REAL MM,L(8)
      COMMON/BLOCK2/TKI,MM,L,RHO,Q,DPC(8),CYC3,X,DC(8,6,4)
C
C       ANDERSEN IMPACTOR NUMBER OF HOLES PER STAGE.
C
      DATA X/264,264,264,264,264,264,264,156,
C
C       BRINK IMPACTOR NUMBER OF HOLES PER STAGE.
C
     11,1,1,1,1,1,1,0,
C
C       U. OF W. IMPACTOR NUMBER OF HOLES PER STAGE.
C
     21,6,12,90,110,110,90,0,
C
C      MRI IMPACTOR NUMBER OF HOLES PER STAGE
C
     38,12,24,24,24,24,12,0/
C
C       ANDERSEN IMPACTOR PLATE SET- 1.
C
C
      DATA DC/.1632,.1233,.0954,.0742,.0577,.0368,.0254,.0255,
C
C       ANDERSEN IMPACTOR PLATE SET- 2.
C
     1.1632,.1253,.0949,.0749,.0569,.0369,.0254,.0257,
C
C       ANDERSEN IMPACTOR PLATE SET- 3.
C
     2.1671,.1281,.0953,.0780,.0547,.0359,.0269,.0253,
C
C       ANDERSEN IMPACTOR PLATE SET- 8.
C
     3.1621,.1263,.0946,.0757,.0581,.0355,.0258,.0245,
C
C       ANDERSEN IMPACTOR PLATE SET- 7.
C
     4.1621,.1249,.0935,.0751,.0563,.0359,.0264,.0250,
C
C       ANDERSEN IMPACTOR PLATE SET- 6.
C
     5.1651,.1240,.0951,.0774,.0565,.0346,.0266,.0245,
C
C       BRINK IMPACTOR STAGE SET = A.
C
     6.3554,.2422,.1779,.1364,.0884,.0705,.0523,.0000,
C
C       BRINK IMPACTOR STAGE SET = B.
C
     7.3618,.2410,.1737,.1366,.0918,.0719,.0566,.0000,
C
C       BRINK IMPACTOR STAGE SET = C.
C
     8.3658,.2460,.1724,.1360,.0896,.0719,.0589,.0000,
C
C       BRINK IMPACTOR STAGE SET = D.
```

```
C
     9.3560,.2461,.1778,.1368,.0937,.0739,.0550,.0000,
     A.0000,.0000,.0000,.0000,.0000,.0000,.0000,.0000,
     B.0000,.0000,.0000,.0000,.0000,.0000,.0000,.0000,
C
C      U. OF W. PILAT IMPACTOR STAGE SET - A.
C
     C1.82372,.5768,.2501,.0808,.0524,.0333,.0245,.0000,
C
C      U. OF W. PILAT IMPACTOR STAGE SET - B.
C
     D1.82372,.5822,.2458,.0802,.0504,.0340,.0323,.0000,
C
C      U. OF W. PILAT IMPACTOR STAGE SET - C.
C
     E1.82372,.5874,.2459,.0807,.0532,.0376,.0260,.0000,
C
C      U. OF W. PILAT IMPACTOR STAGE SET - D.
C
     F1.82372,.5743,.2512,.0793,.0495,.0330,.0229,.000,
     G.0000,.0000,.0000,.0000,.0000,.0000,.0000,.0000,
     H.0000,.0000,.0000,.0000,.0000,.0000,.0000,.0000,
C
C     MRI IMPACTOR
C
     I.870,.476,.205,.118,.084,.052,.052,.000,
     J.000,.000,.000,.000,.000,.000,.000,.000,
     K.000,.000,.000,.000,.000,.000,.000,.000,
     L.000,.000,.000,.000,.000,.000,.000,.000,
     M.000,.000,.000,.000,.000,.000,.000,.000,
     N.000,.000,.000,.000,.000,.000,.000,.000/
      END
      SUBROUTINE CPPLOT(IDGEN,RHO,XMAX,XMIN,YMAX,YMIN,XS,YS)
C***********************************************************************
C*    SUBROUTINE CPPLOT DRAWS THE GRID FOR CUMULATIVE PERCENT MASS
C*    LOADING VS. PARTICLE DIAMETER. IT DRAWS AN ORDINATE NORMAL
C*    PROBABILITY SCALE LABELING IT 'CUMULATIVE PERCENT' AND AN ABSCISSA
C*    LOG10 SCALE LABELING IT 'PARTICLE DIAMETER (MICROMETERS)'.
C*    THE GRID IS LABELED WITH THE IDENTIFICATION LABEL ID AND DENSITY
C*    RHO.
C***********************************************************************
      DIMENSION IDGEN(80)
C
C     THE MINIMUM AND MAXIMUM Y VALUES SHOWN ON THE GRID WILL BE .01
C     AND 99.99 BUT MUST CALL NDTRI IN ORDER TO ESTABLISH THE MINIMUM
C     AND MAXIMUM Y VALUES, YMIN AND YMAX, IN TERMS OF THE NORMAL
C     PROBABILITY SCALE.
C
      CALL NDTRI(0.9999,YMAX,D,IE)
      CALL NDTRI(0.0001,YMIN,D,IE)
C
C     LENGTH IF X - AXIS (IN INCHES).
C
      XINCH=4.5
C
C     LENGTH IF Y - AXIS (IN INCHES).
C
      YINCH=6.5
C
C     XMAX AND XMIN ARE THE MAXIMUM AND MINIMUM X VALUES IN TERMS OF THE
C     LOG10 SCALE. ALSO XMIN IS THE X VALUE OF PEN LOCATION WHEN THIS
C     SUBROUTINE IS CALLED.
C
      XMAX=ALOG10(100.)
      XMIN=ALOG10(.1)
C
C     XS AND YS ARE THE X AND Y SCALE FACTORS (IN INCHES/USER'S UNIT).
C
      XS=XINCH/(XMAX-XMIN)
      YS=YINCH/(YMAX-YMIN)
C
C     YO IS THE Y VALUE OF PEN LOCATION WHEN THIS SUBROUTINE CALLED.
C
      YO=YMIN-2./YS
C
C     SUBROUTINE SCALF STORES THE SCALE FACTORS AND PEN LOCATION
C     COORDINATE VALUES FOR USE BY THE PLOTTER.
C
      CALL SCALF(XS,YS,XMIN,YO)
C
CCC   THIS SECTION DRAWS THE Y - AXIS AND LABELS IT.
C
      CALL FPLOT(0,XMAX,YMIN)
      IMIN=1
      IMAX=25
C
C     SUBROUTINE YPROB DRAWS THE Y - AXIS AND LABELS IT USING A NORMAL
C     PROBABILITY SCALE. THE RANGE IS DETERMINED BY IMIN AND IMAX
C     WHICH ARE INTEGER CODES FOR DESIRED VALUES OF MINIMUM AND MAXIMUM
C     Y VALUES. A '1' CORRESPONDS TO .01 AND '25' CORRESPONDS TO 99.99.
C     THE 4TH ARGUMENT = 0 IS CODE TO LABEL AXIS TO THE LEFT.
```

```
C
      CALL YPROB(XS,YS,XMIN,0,IMIN,IMAX)
      XCS=.15
      YCS=.15
      X=XMIN-1.0/XS
      Y=((YMAX-YMIN)/2.0)+YMIN-((9.0*YCS)/YS)
      PI=3.1415
      CALL FCHAR(X,Y,XCS,YCS,PI/2.)
C
C     WRITE 'CUMULATIVE PERCENT' ALONG Y - AXIS.
C
      WRITE(7,3)
C
CCC   THIS SECTION DRAWS THE X - AXIS AND LABELS IT.
C
      IXRAN=XMAX-XMIN
      CALL XSLBL(XS,YS,XMIN,YMIN,IXRAN,XMIN)
      CALL XLOG(XS,YS,XMAX,YMIN,-1,IXRAN)
      X=((XMAX-XMIN)/2.0)+XMIN-((16.0*XCS)/XS)
      Y=YMIN-(.7/YS)
      CALL FCHAR(X,Y,XCS,YCS,0.)
C
C     WRITE 'PARTICLE DIAMETER (MICROMETERS)' BELOW X - AXIS.
C
      WRITE(7,2)
C
CCC   THIS SECTION WRITES THE IDENTIFICATION LABEL ID AND THE PARTICLE
CCC   DENSITY RHO (IN GM/CC).
C
      X=XMIN
      Y=YMAX+.5/YS
      XCS=.056
      YCS=.100
      DO 30 I=1,79
      J=80-I
      IF(IDGEN(J).NE.IBLAK)GO TO 40
   30 CONTINUE
      J=1
   40 CALL FCHAR(X,Y,XCS,YCS,0.)
      WRITE(7,5)(IDGEN(I),I=1,J)
      X=XMIN
      Y=YMAX+.25/YS
      CALL FCHAR(X,Y,XCS,YCS,0.)
      WRITE(7,6)RHO
      RETURN
    3 FORMAT(1X,'CUMULATIVE PERCENT')
    2 FORMAT(1X,'PARTICLE DIAMETER (MICROMETERS)')
    5 FORMAT(1X,80A1)
    6 FORMAT(1X,'RHO= ',F4.2,'GM/CC')
      END
      SUBROUTINE CUM
C
C        THIS SUBROUTINE CALCULATES THE CUMMULATIVE MASS AND CUMMULATIVE
C        PERCENT DISTRIBUTION AT EACH STAGE.
C
C
      REAL MASS(9),MU
      COMMON/BLOCK1/PS(8),MU,POA,DPA,TCI,FG(5)
      COMMON/BLOCK3/MASS,F,DUR,TKS,CUMM(9),PERCU(9),
     1GRNA,GRNS,GRNAM,GRNSM
      COMMON/BLOCK5/NCUM,MPACTY,MPACNO,NMASS
      SUM=0.0
      DO 50 I=1,NMASS
      SUM=SUM+MASS(I)
      CUMM(I)=SUM
   50 CONTINUE
      DO 60 I=1,NMASS
      PERCU(I)=(CUMM(I)/SUM)*100.0
   60 CONTINUE
C
C        GRNA IS THE TOTAL MASS LOADING IN GRAINS PER ACTUAL CUBIC FOOT.
C
      GRNA=(SUM*15.4324)/(F*DUR)
C
C        GRNS IS THE TOTAL MASS LOADING IN GRAINS PER NORMAL DRY CUBIC FOOT.
C
      GRNS=((SUM*15.4324)/((F*DUR*294.0*POA)/(TKS*1.0)))/(1.0-FG(5))
C
C        GRNAM IS THE TOTAL MASS LOADING IN MILLIGRAMS PER ACTUAL CUBIC
C        METER.
C
      GRNAM=GRNA*2288.34
C
C        GRNSM IS THE TOTAL MASS LOADING IN MILLIGRAMS PER NORMAL DRY
C        CUBIC METER.
C
      GRNSM=GRNS*2288.34
C
C        NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.
C
      RETURN
      END
      SUBROUTINE CUMPCT
C***********************************************************************
C*
C*    SUBROUTINE CUMPCT FINDS THE CUMULATIVE MASS LOADING LESS THAN A
C*    PARTICULAR PARTICLE DIAMETER ACCORDING TO FITTING
C*    FOUND IN PROGRAM SPLIN1. IT EXPRESSES THIS VALUE AS A PERCENT OF
C*    THE TOTAL CUMULATIVE MASS LOADING. THE SUBROUTINE LISTS (ON THE
C*    LINE PRINTER) THE POINT INDEX NUMBER, DIAMETER, AND CUM. PERCENT
C*    MASS LOADING LESS THAN THIS DIAMETER.
C*    ALSO A PLOT IS MADE OF THESE VALUES USING A NORMAL PROBABILITY
C*    (FOR CUM. PERCENT) VS. LOG10 (FOR DIAMETER) GRID.
C*
C***********************************************************************
C
      INTEGER VV
      DOUBLE PRECISION XNDPEN(10),YO(10)
      DIMENSION FILNAM(2)
      DIMENSION IDALL(80),GEMAX(2),GEMIN(2),DMMAX(2),DMMIN(2),DNMAX(2)
      DIMENSION DNMIN(2),DPMAX(2),DPMIN(2),CUMAX(2),CUMIN(2),ID(80)
      DIMENSION DPC(8),CUMG(8),DMDLD(9),GEOMD(9),DNDLD(9)
      DIMENSION FILSPL(2),COE(50,3)
      DIMENSION X1(51),Y1(51)
      COMMON IMPAC,IDALL,RHO1,GEMAX,GEMIN,DMMAX,DMMIN,DNMAX,DNMIN
      COMMON DPMAX,DPMIN,CUMAX,CUMIN,ISIZ1,ISIZ2,ISIZ3
      COMMON IS,NFIT,ID,RHO,DMIN,TKS,PDA,FG(5),DMAX,DPC,CUMG,DMDLD
      COMMON GEOMD,DNDLD,GRNAM,MPLOT,DSMA,VV
      COMMON ISIG,XMAX,XMIN,YMAX,YMIN,XS,YS
      COMMON CYC3,MC3,M00,MS
      COMMON XNDPEN
      DATA FILSPL/'FILSP','LBIN'/
C
      CALL DEFINE(11,507,100,FILSPL,I10,0,0,0)
C
C     DINC - THE LOG10 INCREMENT BETWEEN PRINTED DIAMETERS (D1**10.0)
C            AND THE CUM. % MASS LOADING AT THAT THAT DIAMETER.
C
      DINC=.0357142857
C
C     DLD = LOG10(DIAMETER) = VARIABLE USED BY FITTING FUNCTION PPP.
C           INITIALIZED HERE AS LOG10(.25 MICRONS).
C
      DLD=ALOG10(.25)
C
C     D1 - DIAMETER VARIABLE WHOSE ANTILOG IS PRINTED.
C
      D1=DLD
C
C     DLDF - MAXIMUM LOG10(DIAMETER) VALUE FOR WHICH LOG10(CUM. % MASS
C        LOADING IS TO BE CALCULATED. HERE IT IS SET = TO MAXIMUM X
C        AXIS LIMIT.
C
      DLDF=XMAX
      IF(DMAX.LT.100) DLDF = ALOG10(DMAX)
C
C     SUBROUTINE CPPLOT MAKES A NORMAL PROBABILITY VS. LOG10 GRID,
C     LABELS THE AXES APPROPRIATELY WITH 'CUMULATIVE PERCENT' AND
C     'PARTICLE DIAMETER (MICROMETERS)', WRITES THE IDENTIFICATION LABEL ID
C     AND PARTICLE DENSITY RHO (IN GM/CC) ABOVE THE GRID, AND RETURNS
C     WITH THE MINIMUM AND MAXIMUM AXIS VALUES - XMAX,XMIN,YMAX,YMIN.
```

```
C     AND THE SCALE FACTORS XS AND YS (IN INCHES/USER'S UNIT).
C
      CALL CPPLOT(ID,RHO,XMAX,XMIN,YMAX,YMIN,XS,YS)
C
C     READ NUMBER OF INTERVAL BOUNDARY POINTS NINT (USED IN MAKING
C     FIT TO LOG10(CUM. MASS LOADING) DISTRIBUTION IN SPLIN1), THE
C     POINT VALUES (X1,Y1), AND THE FITTING 2ND DEGREE POLYNOMIAL
C     COEFFICIENTS OVER THE INTERVALS COE.
C
      READ(11'IS)NPOIN
      INT=NPOIN-1
      READ(11'IS)NPOIN,(X1(I),I=1,NPOIN),(Y1(I),I=1,NPOIN),
     1((COE(I,J),J=1,3),I=1,INT)
C
C     WRITE THE IDENTIFICATION CODE ID AND THE DENSITY RHO ON LINE
C     PRINTER.
C
      WRITE(3,901)ID,RHO
C
C     IN THIS LOOP, CALCULATIONS FOR CUM. X START AT LOG10(.25) MICRONS
C     AND ARE MADE AT EVERY .01 INCH ALONG THE AXIS UP TO MAXIMUM X
C     AXIS LIMIT. POINTS ARE PLOTTED FOR ALL OF THESE CALCULATIONS
C     (RESULTING IN A SMOOTH SOLID CURVE). AT CALCULATED INTERVALS A
C     POINT IS LISTED ON THE LINE PRINTER.
C
      DO 750 I=1,601
C
C     DETERMINE THE INTERVAL OF FITTING, NINT, IN WHICH THE DIAMETER
C     LIES.
C
      DO 510 K=2,NPOIN
      L=K
      IF(DLD.LT.X1(K))GO TO 520
  510 CONTINUE
  520 NINT=L-1
      PPP=COE(NINT,1)
C
C     PPP=LOG10(CUMULATIVE MASS LOADING)
C
      DO 530 L=2,3
  530 PPP=PPP+COE(NINT,L)*DLD**(L-1)
C
C     PPP HERE IS CHANGED BACK TO CUM. MASS LOADING AND DIVIDED BY
C     MAXIMUM MASS LOADING GRNAM TO YIELD PPP = CUM. FRACTIONAL MASS
C     LOADING WHICH IS THE PLOTTING ORDINATE VALUE.
C
      PPP=(10.0**PPP)/GRNAM
C
C     DPLOT = ALOG10(DIAMETER) WHICH IS THE PLOTTING ABSCISSA VALUE
C
      DPLOT=DLD
C
C     SUBROUTINE NDTRI TAKES THE FRACTION PPP AND RETURNS ITS NORMAL
C     PROBABILITY EQUIVALENT VALUE YV.
C
      CALL NDTRI(PPP,YV,D,IE)
C
C     IF PPP > .9999, YV IS SET = TO AN ARBITRARY NUMBER > THE NORMAL
C     PROBABILITY VALUE FOR .9999 WHICH IS +3.7191244.
C
```

```
      IF(PPP.GT..9999)YV=4.0
C
C     IF PPP < .0001, YV IS SET = TO AN ARBITRARY NUMBER < THE NORMAL
C     PROBABILITY VALUE FOR .0001 WHICH IS -3.7191244.
C
      IF(PPP.LT..0001)YV=-4.0
C
C     CHECK DPLOT AND YV TO SEE IF THEY ARE WITHIN PLOTTING LIMITS. IF
C     NOT, XVAL (OR YVAL) SETS THE INPUT VARIABLE= TO A VALUE WHICH
C     LIES .15 INCH OUTSIDE GRID.
C
      YN=YVAL(YV,YMAX,YMIN,YS)
      XN=XVAL(DPLOT,XMAX,XMIN,XS)
C
C     FPLOT MOVES PEN TO (XN,YN) ON EACH TRAVERSE OF 'DO 750' LOOP
C     DRAWING SMOOTH CURVE FOR CUM. % MASS LOADING VS. DIAMETER.
C
      IF(I.EQ.1)GO TO 725
      CALL FPLOT(0,XN,YN)
      GO TO 730
  725 CALL FPLOT(-2,XN,YN)
C
C     AT D1 = DLD, DIAMETER AND CUMULATIVE PERCENT ARE PRINTED.
C     THEN D1 WILL BE INCREMENTED BY DINC SO THAT NO VALUES WILL BE PRINTED
C     AGAIN UNTIL DLD > OR = D1.
C
  730 IF(D1-DLD)735,735,740
C
C     DPLOT IS CHANGED FROM LOG10(DIAMETER) TO DIAMETER FOR PRINT OUT.
C
  735 DPLOT=10.0**DPLOT
C
C     PPP IS CHANGED FROM CUM. FRACTIONAL MASS LOADING TO CUM. PERCENT
C     MASS LOADING FOR PRINT OUT.
C
      PPP=PPP*100.0
      J=J+1
C
C     WRITE ON LINE PRINTER POINT INDEX NUMBER, DIAMETER, AND CUM. PERCENT
C     MASS LOADING LESS THAN THIS DIAMETER.
C
      WRITE(3,905)J,DPLOT,PPP
C
C     INCREMENT D1
C
      D1=D1+DINC
C
C     INCREMENT DLD
C
  740 DLD=DLD+.01/XS
C
C     UNLESS THIS DIAMETER VALUE IS = OR > MAXIMUM SPECIFIED PLOTTING
C     DIAMETER VARIABLE DLDF, CONTINUE WITH CALCULATIONS FOR NEXT
C     DIAMETER.
C
      IF(DLD-DLDF)750,795,795
  750 CONTINUE
C
C     AT END OF PLOTTING, RAISE PEN AND MOVE IT TO BASE OF PLOTTER 4.5
C     INCHES BEYOND GRID - READY FOR NEXT PLOT.
```

```
C
  795 XN=XMAX+4.5/XS
      YN=YMIN-2./YS
      CALL FPLOT(+1,XN,YN)
  901 FORMAT(1H1,//,80A1/,1X,'RHO= ',F4.2//,51X,'CUMULATIVE'/
     1,8X,'INTERVAL',14X,'DIAMETER',8X,'PERCENT CONCENTRATION'/,
     230X,'(MICRONS)'//)
  905 FORMAT(11X,I2,4X,2(13X,1PE9.2)/)
      RETURN
      END
      SUBROUTINE CUT
C
C       THIS SUBROUTINE CALCULATES THE STAGE CUT POINTS OR D50'S BASED
C       ON EQUATIONS DEVELOPED BY RANZ AND WONG GIVEN IN "IMPACTION
C       OF DUST AND SMOKE PARTICLES ON SURFACE AND BODY COLLECTORS",
C       INDUSTRIAL AND ENGINEERING CHEMISTRY, 1952.
C
C
      INTEGER X(8,4)
      REAL MM,MU,L(8)
      DIMENSION SRPSI(8,6,4),SUB(8,4)
      COMMON/BLOCK1/PS(8),MU,POA
      COMMON/BLOCK2/TKI,MM,L,RHO,Q,DPC(8),CYC3,X,DC(8,6,4)
      COMMON/BLOCK5/NCUM,MPACTY,MPACNO,NMASS,NAERO
C
C***********************************************************************COMK
C*                                                                     *COMK
C*    ANDERSEN IMPACTOR PLATE SET = 1                                  *COMK
C*                                                                     *COMK
C***********************************************************************COMK
      DATA SRPSI/.305,.430,.410,.385,.328,.319,.364,.283,               COMK
C***********************************************************************COMK
C*                                                                     *COMK
C*    ANDERSEN IMPACTOR PLATE SET = 2                                  *COMK
C*                                                                     *COMK
C***********************************************************************COMK
     1.305,.430,.410,.385,.332,.313,.365,.280,                          COMK
C***********************************************************************COMK
C*                                                                     *COMK
C*    ANDERSEN IMPACTOR PLATE SET = 3                                  *COMK
C*                                                                     *COMK
C***********************************************************************COMK
     2.305,.430,.410,.385,.341,.320,.331,.274,                          COMK
C***********************************************************************COMK
C*                                                                     *COMK
C*    ANDERSEN IMPACTOR PLATE SET = 8                                  *COMK
C*                                                                     *COMK
C***********************************************************************COMK
     3.305,.430,.410,.385,.342,.370,.352,.272,                          COMK
C***********************************************************************COMK
C*                                                                     *COMK
C*    ANDERSEN IMPACTOR PLATE SET = 7                                  *COMK
C     THIS IS AN AVERAGE FOR STAGES 5,6,7,8.                            COMK
C*                                                                     *COMK
C***********************************************************************COMK
     4.305,.430,.410,.385,.337,.331,.350,.277,                          COMK
C***********************************************************************COMK
C*                                                                     *COMK
C*    ANDERSEN IMPACTOR PLATE SET = 6                                  *COMK
C*                                                                     *COMK
C***********************************************************************COMK
     5.305,.430,.410,.385,.344,.335,.339,.278,                          COMK
C***********************************************************************COMK
C*                                                                     *COMK
C*    BRINK IMPACTOR STAGE SET = A                                     *COMK
C*                                                                     *COMK
C***********************************************************************COMK
     6.322,.322,.338,.345,.258,.317,.229,.000,                          COMK
C***********************************************************************COMK
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C*                                                                     *COMK
C*    BRINK IMPACTOR STAGE SET - B                                     *COMK
C*                                                                     *COMK
C***********************************************************************COMK
     7.322,.322,.349,.330,.302,.345,.175,.000,                          COMK
C***********************************************************************COMK
C*                                                                     *COMK
C*    BRINK IMPACTOR STAGE SET - C                                     *COMK
C*                                                                     *COMK
C***********************************************************************COMK
     8.322,.322,.351,.388,.330,.350,.273,.000,                          COMK
C***********************************************************************COMK
C*                                                                     *COMK
C*    BRINK IMPACTOR STAGE SET - D                                     *COMK
C*                                                                     *COMK
C***********************************************************************COMK
     9.322,.322,.346,.354,.297,.337,.226,.000,                          COMK
     A.000,.000,.000,.000,.000,.000,.000,.000,
     B.000,.000,.000,.000,.000,.000,.000,.000,                          COMK
C***********************************************************************COMK
C*                                                                     *COMK
C*    U. OF W. PILAT IMPACTOR STAGE SET - A                            *COMK
C*                                                                     *COMK
C***********************************************************************COMK
     C.144,.330,.371,.271,.308,.373,.349,.000,                          COMK
C***********************************************************************COMK
C*                                                                     *COMK
C*    U. OF W. PILAT IMPACTOR STAGE SET - B                            *COMK
C*                                                                     *COMK
C***********************************************************************COMK
     D.144,.330,.371,.322,.313,.340,.337,.000,
C***********************************************************************COMK
C*                                                                     *COMK
C*    U. OF W. PILAT IMPACTOR STAGE SET - C                            *COMK
C*                                                                     *COMK
C***********************************************************************COMK
     E.144,.330,.371,.320,.295,.363,.312,.000,                          COMK
C***********************************************************************
C*
C*    U. OF W. PILAT IMPACTOR STAGE SET - D
C*
C***********************************************************************
     F.144,.330,.371,.319,.321,.389,.354,.000,
     G.000,.000,.000,.000,.000,.000,.000,.000,                          COMK
     H.000,.000,.000,.000,.000,.000,.000,.000,                          COMK
C***********************************************************************
C*
C*    HRI STAGE SET - A
C*
C***********************************************************************
     I.11,.25,.35,.34,.29,.35,.40,0.0,
     J.000,.000,.000,.000,.000,.000,.000,.000,
     K.000,.000,.000,.000,.000,.000,.000,.000,
     L.000,.000,.000,.000,.000,.000,.000,.000,
     M.000,.000,.000,.000,.000,.000,.000,.000,
     N.000,.000,.000,.000,.000,.000,.000,.000/
      DATA SUB/9.5,6.0,4.0,2.8,1.75,.90,.54,.36,
     16.0,3.15,1.69,1.10,.57,.33,.20,.00,
     238.0,15.0,6.3,3.1,1.8,0.9,0.49,0.00,
     39.1,9.2,4.9,2.10,1.10,.69,.52,0.0/
```

```
C
C        THIS ITERATIVE LOOP CONTINUES UNTIL CONVERGENCE WITHIN 0.1%.
C
C
      DO 30 I=1,NCUM
      C=0.0
      DPC(I)=SUB(I,MPACTY)
 4    DPCI=DPC(I)
      IF(NAERO.NE.1.OR.RHO.GT.1.0)GO TO 5
      C=1.0
      GO TO 6
 5    C=1.0+(2.0*L(I)/(DPC(I)*1.E-4))*(1.23+0.41*EXP(-.44*DPC(I)*1.E-4
     1/L(I))))
 6    DPC(I)=1.43E04*SRPSI(I,MPACNO,MPACTY)/.38*(SQRT(MU*X(I,MPACTY)
     1*(DC(I,MPACNO,MPACTY)**3)*PS(I)/(RHO*Q*472.0*POA*C)))
      IF(ABS(1.0-(DPC(I)/DPCI))-0.001) 30,30,4
  30  CONTINUE
      IF(MPACTY.NE.2)RETURN
      CYC3=(199.5*SQRT(MU/(RHO*Q)))
      RETURN
      END
      SUBROUTINE DMDNGD
C
C
C      THIS SUBROUTINE CALCULATES THE SIZE DISTRIBUTION ON A MASS BASIS
C      AND ON A NUMBER BASIS. ALSO, GEOM. MEAN DIAMETERS ARE FOUND.
C
      REAL MM,L(8)
      DIMENSION DIFF(9)
      COMMON/BLOCK2/TKI,MM,L,RHO,Q,DPC(8),CYC3
      COMMON/BLOCK4/RA,REYN1(7),REYN2(7),FD(7),MC3,MS,DMAX,GGRNS(9),M00,
     1DMDLD(9),DNDLD(9),GEOMD(9)
      COMMON/BLOCK5/NCUM,MPACTY
  506 FORMAT(1H0,2X,'GEO. MEAN DIA. (MICROMETERS)',11X,7(1PE9.2,1X),11X,
     11PE9.2,//3X,'DM/DLOGD (MG/DNCM)',21X,7(1PE9.2,1X),11X,1PE9.2,//3X,
     2'DN/DLOGD (NO. PARTICLES/DNCM)',10X,7(1PE9.2,1X),11X,1PE9.2)
  507 FORMAT(1H0,2X,'GEO. MEAN DIA. (MICROMETERS)',11X,9(1PE9.2,1X),//3X
     1,'DM/DLOGD (MG/DNCM)',21X,9(1PE9.2,1X),//3X,'DN/DLOGD (NO. PARTICL
     2ES/DNCM)',10X,9(1PE9.2,1X))
  508 FORMAT(1H0,2X,'GEO. MEAN DIA. (MICROMETERS)',21X,6(1PE9.2,1X),11X,
     11PE9.2,//3X,'DM/DLOGD (MG/DNCM)',31X,6(1PE9.2,1X),11X,1PE9.2,//3X,
     2'DN/DLOGD (NO. PARTICLES/DNCM)',20X,6(1PE9.2,1X),11X,1PE9.2)
  504 FORMAT(1H0,2X,'GEO. MEAN DIA. (MICROMETERS)',21X,8(1PE9.2,1X),//3X
     1,'DM/DLOGD (MG/DNCM)',31X,8(1PE9.2,1X),//3X,'DN/DLOGD (NO. PARTICL
     2ES/DNCM)',20X,8(1PE9.2,1X))
  509 FORMAT(1H0,2X,'GEO. MEAN DIA. (MICROMETERS)',31X,5(1PE9.2,1X),11X,
     11PE9.2,//3X,'DM/DLOGD (MG/DNCM)',41X,5(1PE9.2,1X),11X,1PE9.2,//3X,
     2'DN/DLOGD (NO. PARTICLES/DNCM)',30X,5(1PE9.2,1X),11X,1PE9.2)
  510 FORMAT(1H0,2X,'GEO. MEAN DIA. (MICROMETERS)',31X,7(1PE9.2,1X),//3X
     1,'DM/DLOGD (MG/DNCM)',41X,7(1PE9.2,1X),//3X,'DN/DLOGD (NO. PARTICL
     2ES/DNCM)',30X,7(1PE9.2,1X))
 3115 FORMAT(1H0,2X,'GEO. MEAN DIA. (MICROMETERS)',11X,9(1PE9.2,1X),//3X
     1,'DM/DLOGD (MG/DNCM)',21X,9(1PE9.2,1X),//3X,'DN/DLOGD (NO. PARTICL
     IES/DNCM)',10X,9(1PE9.2,1X))
 6115 FORMAT(1H0,2X,'GEO. MEAN DIA. (MICROMETERS)',13X,8(1PE9.2,1X),//3X
     1,'DM/DLOGD (MG/DNCM)',23X,8(1PE9.2,1X),//3X,'DN/DLOGD (NO. PARTICL
     IES/DNCM)',12X,8(1PE9.2,1X))
       GO TO (260,10,360,360),MPACTY
C
C        FOR A BRINK IMPACTOR USED IN A CONFIGURATION OF CYCLONE,S0,S1,...S5,
C        STATEMENTS 10 THUR 74 APPLY TO THE CALCULATIONS OF DMDLD(I),GEOMD(I)
C        AND DNDLD(I).
C
   10 IF(MC3)50,50,60
   60 NS=MS+3
      NS1=NS-1
C
C        DIFF(I) IS THE DIFFERENCE IN THE COMMON LOGS OF THE STAGE D50'S.
C
      DIFF(1)=ALOG10(DMAX)-ALOG10(CYC3)
      DIFF(2)=ALOG10(CYC3)-ALOG10(DPC(1))
      DO 71 I=1,MS
   71 DIFF(I+2)=ALOG10(DPC(I))-ALOG10(DPC(I+1))
      DIFF(NS)=0.30103
C
C        DMDLD(I) IS A DIFFERENTIAL SIZE DISTRIBUTION ON A MASS BASIS.
C
      DO 72 I=1,NS1
   72 DMDLD(I)=GGRNS(I)/DIFF(I)
      DMDLD(NS)=GGRNS(9)/DIFF(NS)
```

```
C
C        GEOMD(I) IS THE GEOMETRIC MEAN OF THE STAGE D50'S.
C
      GEOMD(1)=SQRT(DMAX*CYC3)
      GEOMD(2)=SQRT(CYC3*DPC(1))
      DO 73 I=3,NS1
   73 GEOMD(I)=SQRT(DPC(I-2)*DPC(I-1))
      GEOMD(NS)=0.707107*DPC(7)
C
C        DNDLD(I) IS THE NUMBER OF PARTICLES PER DRY NORMAL CUBIC METER
C        ITS GEOMETRIC MEAN DIAMETER ON THAT STAGE.
C
      DO 74 I=1,NS
   74 DNDLD(I)=((6.*DMDLD(I))/(RHO*3.141592*GEOMD(I)**3))*1.E09
C
C        WRITE THE GEOMD(I),DMDLD(I), AND DNDLD(I).
C
      IF(MS-5)75,75,76
   75 WRITE(3,506) (GEOMD(I),I=1,8),(DMDLD(I),I=1,8),(DNDLD(I),I=1,8)
      GO TO 150
   76 WRITE(3,507) (GEOMD(I),I=1,9),(DMDLD(I),I=1,9),(DNDLD(I),I=1,9)
      GO TO 150
C
C        FOR A BRINK IMPACTOR USED IN A CONFIGURATION OF S0,S1,S2,...S5,SF
C        STATEMENTS 50 THRU 114 APPLY TO THE CALCULATIONS OF DMDLD(I),GEOMD(I
C        AND DNDLD(I).
C
   50 IF(MOO)90,90,100
  100 NS=MS+2
      NS1=NS-1
      DIFF(1)=ALOG10(DMAX)-ALOG10(DPC(1))
      DO 111 I=1,MS
  111 DIFF(I+1)=ALOG10(DPC(I))-ALOG10(DPC(I+1))
      DIFF(NS)=0.30103
      DO 112 I=1,NS1
  112 DMDLD(I)=GGRNS(I+1)/DIFF(I)
      DMDLD(NS)=GGRNS(9)/DIFF(NS)
      GEOMD(1)=SQRT(DMAX*DPC(1))
      DO 113 I=2,NS1
  113 GEOMD(I)=SQRT(DPC(I-1)*DPC(I))
      GEOMD(NS)=0.707107*DPC(NS1)
      DO 114 I=1,NS
  114 DNDLD(I)=((6.*DMDLD(I))/(RHO*3.141592*GEOMD(I)**3))*1.E09
C
C        WRITE THE GEOMD(I),DMDLD(I), AND DNDLD(I).
C
      IF(MS-5)115,115,116
  115 WRITE(3,508) (GEOMD(I),I=1,7),(DMDLD(I),I=1,7),(DNDLD(I),I=1,7)
      GO TO 150
  116 WRITE(3,504) (GEOMD(I),I=1,8),(DMDLD(I),I=1,8),(DNDLD(I),I=1,8)
      GO TO 150
C
C        FOR A BRINK IMPACTOR USED IN A CONFIGURATION OF S1,S2,S3,...S5,SF
C        STATEMENTS 90 THRU 134 APPLY TO THE CALCULATIONS OF DMDLD(I),GEOMD(I
C        AND DNDLD(I).
C
   90 NS=MS+1
      MSM1=MS-1
      DIFF(1)=ALOG10(DMAX)-ALOG10(DPC(2))
      DO 131 I=1,MSM1
  131 DIFF(I+1)=ALOG10(DPC(I+1))-ALOG10(DPC(I+2))
      DIFF(NS)=0.30103
      DO 132 I=1,NS
  132 DMDLD(I)=GGRNS(I+2)/DIFF(I)
      DMDLD(NS)=GGRNS(9)/DIFF(NS)
      GEOMD(1)=SQRT(DMAX*DPC(2))
      DO 133 I=2,NS
  133 GEOMD(I)=SQRT(DPC(I)*DPC(I+1))
      GEOMD(NS)=0.707107*DPC(NS)
      DO 134 I=1,NS
  134 DNDLD(I)=((6.*DMDLD(I))/(RHO*3.141592*GEOMD(I)**3))*1.E09
C
C        WRITE THE GEOMD(I),DMDLD(I), AND DNDLD(I).
C
      IF(NS-5)135,135,136
  135 WRITE(3,509) (GEOMD(I),I=1,6),(DMDLD(I),I=1,6),(DNDLD(I),I=1,6)
      GO TO 150
  136 WRITE(3,510) (GEOMD(I),I=1,7),(DMDLD(I),I=1,7),(DNDLD(I),I=1,7)
      GO TO 150
  260 NS=8
      GO TO 270
  360 NS=7
  270 NS1=NS+1
      NSM1=NS-1
      DIFF(1)=ALOG10(DMAX)-ALOG10(DPC(1))
      DO 271 I=1,NSM1
  271 DIFF(I+1)=ALOG10(DPC(I))-ALOG10(DPC(I+1))
      DIFF(NS1)=0.30103
      DO 272 I=1,NS1
  272 DMDLD(I)=GGRNS(I)/DIFF(I)
      GEOMD(1)=SQRT(DMAX*DPC(1))
      DO 273 I=2,NS
  273 GEOMD(I)=SQRT(DPC(I-1)*DPC(I))
      GEOMD(NS1)=0.707107*DPC(NS)
      DO 274 I=1,NS1
  274 DNDLD(I)=((6.*DMDLD(I))/(RHO*3.141592*GEOMD(I)**3))*1.E09
      GO TO (275,275,375,375),MPACTY
C
C        WRITE THE GEOMD(I),DMDLD(I), AND DNDLD(I).
C
  275 WRITE(3,3115) (GEOMD(I),I=1,9),(DMDLD(I),I=1,9),(DNDLD(I),I=1,9)
      GO TO 150
  375 WRITE(3,6115) (GEOMD(I),I=1,8),(DMDLD(I),I=1,8),(DNDLD(I),I=1,8)
  150 CONTINUE
      RETURN
      END
   180 CARDS ON TAPE
STOP  000000
```

```
      SUBROUTINE FPLOT(I,X,Y)
C
      DATA  SX/100./,SY/100./,RINC/100./,LOTS/7/
C
      RND(XX)=XX+SIGN(.5,XX)
C
      J=I
      MODE=8
      IF (J) 60,60,50
   50 MODE=3-(J-2*(J/2))
   60 IX=RND(SX*X)
      IY=RND(SY*Y)
      WRITE (LOTS) MODE,IX,IY
      J=-J
      IF (J) 70,70,65
   65 MODE=1-(J-2*(J/2))
      WRITE (LOTS) MODE
   70 RETURN
C
      ENTRY SCALF (XS,YS,XZ,YZ)
      MODE=7
      SX=RINC*XS
      SY=RINC*YS
      IX=RND(SX*XZ)
      IY=RND(SY*YZ)
      WRITE (LOTS) MODE,IX,IY
      RETURN
C
      ENTRY FCHAR(XB,YB,W,H,TH)
      IX=RND(RINC*W)
      IY=RND(RINC*H)
      IF(IX.LE.0) IX=10
      IF(IY.LE.0) IY=10
      JSIN=65536*    (SIN(TH))
      JCOS=65536*    (COS(TH))
      MODE=10
      WRITE(LOTS) MODE,IX,IY,JSIN,JCOS
      IX=RND(SX*XB)
      IY=RND(SY*YB)
      MODE=2
      WRITE (LOTS) MODE,IX,IY
      RETURN
C
C
      ENTRY FGRID (I,X,Y,U,M)
      MODE=2
      IX0=RND(SX*X)
      IY0=RND(SY*Y)
      WRITE(LOTS)MODE,IX0,IY0
      MODE=1
      WRITE(LOTS) MODE
      MODE=9
      MODE8=8
      LIMIT=M+1
      IF (I.EQ.2*(I/2)) GO TO 100
      MY2=0
      MY1=0
      MX1=5
      MX2=-10
      IX=IXO
      GO TO 150
  100 MY1=5
      MY2=-10
      MX1=0
      MX2=0
      IY=IYO
  150 DO 200 INDEX=1,LIMIT
      UI=INDEX*U
      IF(I.EQ.2*(I/2)) GO TO 160
      IY=RND(SY*UI)
      IF(I.EQ.3) IY=-IY
      IY=IYO+IY
      GO TO 170
  160 IX=RND(SX*UI)
      IF(I.EQ.2) IX=-IX
      IX=IXO+IX
  170 WRITE(LOTS) MODE,MX1,MY1
      WRITE (LOTS) MODE,MX2,MY2
      WRITE (LOTS) MODE,MX1,MY1
      IF (INDEX.EQ.LIMIT) GO TO 200
      WRITE(LOTS) MODE8,IX,IY
  200 CONTINUE
      MODE=0
      WRITE (LOTS) MODE
      RETURN
      END
      SUBROUTINE JOE1
C***********************************************************************
C*
C*    SUBROUTINE JOE1 PLOTS THE FITTED CURVE FOR THE CUMULATIVE MASS
C*    LOADING (MG/ACM) VS. DIAMETER (MICRONS) .  THE GRID HAS ALREADY
C*    BEEN DRAWN BY WALLY1.
C*
C***********************************************************************
      INTEGER VV
      DOUBLE PRECISION XNDPEN(10),YO(10)
      DOUBLE PRECISION DLOG10
      DIMENSION IDALL(80),GEMAX(2),GEMIN(2),DMMAX(2),DMMIN(2),DNMAX(2)
      DIMENSION DNMIN(2),DPMAX(2),DPMIN(2),CUMAX(2),CUMIN(2),ID(80)
      DIMENSION DPC(8),CUMG(8),DMDLD(9),GEOMD(9),DNDLD(9)
      DIMENSION FILSPL(2),COE(50,3)
      DIMENSION X1(51),Y1(51)
      COMMON IMPAC,IDALL,RHO1,GEMAX,GEMIN,DMMAX,DMMIN,DNMAX,DNMIN
      COMMON DPMAX,DPMIN,CUMAX,CUMIN,ISIZ1,ISIZ2,ISIZ3
      COMMON IS,NFIT,ID,RHO,DMIN,TKS,POA,FG(5),DMAX,DPC,CUMG,DMDLD
      COMMON GEOMD,DNDLD,GRNAM,MPLOT,DSMA,VV
      COMMON ISIG,XMAX,XMIN,YMAX,YMIN,XS,YS
      COMMON CYC3,MC3,M00,MS
      COMMON XNDPEN
      DATA FILSPL/'FILSP','LBIN'/
      CALL DEFINE(11,507,100,FILSPL,I10,0,0,0)
C
C     NPOIN - NO. OF INTERVAL BOUNDARY POINTS DEFINED FOR CURVE FIT
C     TO LOG10(CUMULATIVE MASS LOADING) VS. LOG10(D50).
C     (X1,Y1) - BOUNDARY POINT VALUES
C     COE - FITTING SECOND DEGREE POLYNOMIAL COEEFICIENTS FOR EACH OF
C     THE INT INTERVALS.
C
      READ(11'IS)NPOIN
      INT=NPOIN-1
      READ(11'IS)NPOIN,(X1(I),I=1,NPOIN),(Y1(I),I=1,NPOIN),
     1((COE(I,J),J=1,3),I=1,INT)
C
C     DSMA - SMALLEST DIAMETER PLOTTED FOR THIS RUN. FIRST VALUE OF
C     DIAMETER VARIABLE DLD IS SET HERE.
C     DLDF - LAST VALUE FOR WHICH CUMULATIVE MASS LOADING VALUE IS
C     FOUND. HERE IT IS SET = TO THE MAXIMUM X LIMIT OF PLOT.
C
C     NOTE: THE EQUATION USES LOG10(ORIGINAL VALUE) SINCE THIS IS
C     FORM OF VARIABLE USED TO OBTAIN FIT. (I.E. BOTH DIAMETER AND
C     CUM. MASS LOADING ARE PUT IN THIS FORM FOR FITTING.)
C
      DLD=ALOG10(DSMA)
      DLDF=XMAX
      IF(DMAX.LT.100.) DLDF=ALOG10(DMAX)
C
C     THIS LOOP CALCULATES A LOG10(CUM. MASS LOADING) FOR EACH
C     LOG10(DIAMETER) AND PLOTS LOG10(CUM. MASS LOADING) VS.
C     LOG10(DIAMETER).
C
      DO 750 I=1,601
C
C     THIS LOOP FINDS THE INTERVAL NINT WHICH CONTAINS THE DIAMETER
C     VARIABLE VALUE DLD.
C
```

```
      DO 20 K=2,NPOIN
      J=K
      IF(DLD.LT.X1(K))GO TO 25
   20 CONTINUE
   25 NINT=J-1
C
C     CALCULATE LOG10(CUMULATIVE MASS LOADING) PPP USING APPROPRIATE 2ND
C     DEGREE POLY. COEEFICIENTS, COE(NINT,I),I=1,3.
C
C
      PPP=COE(NINT,1)
      DO 30 L=2,3
      PPP=PPP+COE(NINT,L)*DLD**(L-1)
   30 CONTINUE
C
C     LOG10(CUM. MASS LOAD.) VS. LOG10(DIAMETER) IS PLOTTED.
C     XNEX=XN UNLESS XNEX FALLS OUTSIDE BOUNDARIES OF GRID, THEN
C     FUNCTION XVAL ASSIGNS A VALUE TO XNEX JUST OUTSIDE AXIS.
C     YVAL IS A SIMILAR FUNCTION FOR YNEX.
C
      XNEX=DLD
      XN=XVAL(XNEX,XMAX,XMIN,XS)
      YNEX=PPP
      YN=YVAL(YNEX,YMAX,YMIN,YS)
      IF(I.EQ.1)GO TO 725
      CALL FPLOT(0,XN,YN)
      GO TO 730
  725 CALL FPLOT(-2,XN,YN)
C
C     LOG10 DIAMETER IS INCREMENTED TO THE VALUE CORRESPONDING TO 1/100
C     INCH FURTHER ALONG THE AXIS (SMALLEST INCREMENT POSSIBLE) AND CHECK
C     MADE FOR LAST DESIRED DIAMETER. PLOTTING CONTINUES UNTIL DLD > DLDF.
C
  730 DLD=DLD+.01/XS
C
      IF(DLD-DLDF)750,795,795
  750 CONTINUE
  795 CALL FPLOT(+1,XN,YN)
C
C     MOVE PEN TO BASE LINE OF PLOT PAPER AND 4.5NCHES BEYOND XMAX.
C     LEAVE PEN UP, READY FOR NEXT PLOT CALLED.
C
  900 XN=XMAX+4.5/XS
      YN=YMIN-2./YS
      CALL FPLOT(0,XN,YN)
      RETURN
      END
      SUBROUTINE JOE2
C************************************************************************
C*    SUBROUTINE JOE2 CALCULATES AND PLOTS CHANGE IN MASS CONCENTRATION,
C*    DM/DLOG (MG/DNM3) VS PARTICLE DIAMETER (MICRONS) USING THE
C*    DERIVATIVE EQUATION FOR CUMUALTIVE MASS LOADING FIT, POINTS ARE
C*    PLOTTED ON GRID MADE BY WALLY2, A LINE PRINT OUT OF THE POINT
C*    VALUES IS MADE, A SIMILAR PLOT AND PRINT OUTPUT ARE MADE FOR
C*    CHANGE IN NO. CONCENTRATION, DN/DLOGD (NO/DNM3), THE GRID USED HERE IS
C*    PRODUCED IN WALLY3.
C************************************************************************
      INTEGER VV
      DOUBLE PRECISION XNDPEN(10),YO(10)
      DOUBLE PRECISION DLOG10
      DIMENSION IDALL(80),GEMAX(2),GEMIN(2),DMMAX(2),DMMIN(2),DNMAX(2)
      DIMENSION DNMIN(2),DPMAX(2),DPMIN(2),CUMAX(2),CUMIN(2),ID(80)
      DIMENSION DPC(8),CUMG(8),DMDLD(9),GEOMD(9),DNDLD(9)
      DIMENSION X1(51),Y1(51)
      DIMENSION FILSPL(2),COE(50,3)
      COMMON IMPAC,IDALL,RHO1,GEMAX,GEMIN,DMMAX,DMMIN,DNMAX,DNMIN
      COMMON DPMAX,DPMIN,CUMAX,CUMIN,ISIZ1,ISIZ2,ISIZ3
      COMMON IS,NFIT,ID,RHO,DMIN,TKS,PDA,FG(5),DMAX,DPC,CUMG,DMDLD
      COMMON GEOMD,DNDLD,GRNAM,MPLOT,DSMA,VV
      COMMON ISIG,XMAX,XMIN,YMAX,YMIN,XS,YS
      COMMON CYC3,MC3,M00,MS
      COMMON XNDPEN
      DATA FILSPL/'FILSP','LBIN'/
      CALL DEFINE(11,507,100,FILSPL,I10,0,0,0)
C
C     ISIG=1 - FINDING CHANGE IN MASS CONCENTRATION, DM/DLOGD
C     ISIG=6 - FINDING CHANGE IN NUMBER CONCENTRATION, DN/DLOGD
C
C
C     WRITE COLUMN HEADINGS AT TOP OF PAGE ON LINE PRINTER:
C     'INTERVAL', 'DIAMETER', AND 'CHANGE IN MASS CONCENTRATION (MG/DNM3)'
C     OR 'CHANGE IN NUMBER CONCENTRATION (NO./DNM3)'.
C
      IF(ISIG.EQ.1)WRITE(3,140)ID,RHO
      IF(ISIG.EQ.6)WRITE(3,240)ID,RHO
C
C     DIVIDE THE X AXIS BETWEEN .25 MICRONS AND 100 MICRONS INTO 35
C     LOG10 INCREMENTS, EACH OF THESE INCREMENT LOG10 DIAMETER 'SLOTS'
C     WILL HAVE CORRESPONDING CHANGES IN MASS AND NUMBER CONCENTRATIONS,
C     HERE, DINC = (LOG10(100.0)-LOG10(.25))/35 = .0714285714 AND
C     IS THE INCREMENT BETWEEN VALUES OF THE INDEPENDENT VARIABLE D1
C     = LOG10(DIAMETER).
C     ACTUALLY THE CALCULATIONS HERE USE THE DERIVATIVE EQUATION
C     (2ND 'DELM' BELOW) WHICH GIVES THE LIMIT OF THIS CHANGE AT THE
C     INDICATED DIAMETER.
C
      DINC=.0714285714
      D1=ALOG10(.25)
      DLDF = XMAX
      IF(DMAX.LT.100.) DLDF = ALOG10(DMAX)
      READ(11'IS)NPOIN
      INT=NPOIN-1
      READ(11'IS)NPOIN,(X1(I),I=1,NPOIN),(Y1(I),I=1,NPOIN),
     1((COE(I,J),J=1,3),I=1,INT)
      DO 100 I=1,50
C
```

```
C     D1=LOG10(DIAMETER). THIS IS VARIABLE USED FOR FITTING AND PLOTTING.
C     DPLOT=DIAMETER (MICRONS). THIS IS PRINTED VALUE.
C
      DPLOT=10.0**D1
C
C
C     DETERMINE THE INTERVAL OF FITTING, NINT, IN WHICH THE DIAMETER
C     LIES.
C
      DO 320 J=2,NPOIN
      K=J
      IF(D1.LT.X1(K))GO TO 325
  320 CONTINUE
  325 NINT=K-1
C
C     CALCULATE DERIVATIVE OF FITTED POLYNOMIAL, DELM.
C     (NOTE: THIS IS DERIVATIVE WITH RESPECT TO LOG10(DIAMETER.)
C
      DEL1=COE(NINT,2)+COE(NINT,3)*2*D1
  343 PPP=COE(NINT,1)
      DO 344 L=2,3
  344 PPP=PPP+COF(NINT,L)*D1**(L-1)
      DELM=DEL1*(10.0**PPP)*2.302585
C
C     FIT WAS MADE TO CUM. MASS POINTS IN MG/ACM. THIS STEP CONVERTS
C     TO MG/DNM3.
C
   45 DELM=(DELM/((294.0*POA)/(TKS*1.0)))/((100.0-FG(5))/100.0)
C
C     GIVEN DENSITY OF PARTICLES AND CHANGE IN MASS CONCENTRATION,
C     CHANGE IN NO. CONCENTRATION IS CALCULATED.
C
      DELN=((6.*DELM)/(RHO*3.141592*(DPLOT**3)))*1.0E09
C
C     DEL CAN REPRESENT EITHER CHANGE IN MASS CONCENTRATION (ISIG=1)
C     OR CHANGE IN NO. CONCENTRATION (ISIG=6).
C
      IF(ISIG.EQ.1)DEL=DELM
      IF(ISIG.EQ.6)DEL=DELN
C
      IF(DEL)60,60,65
C
C     AN EXTREMELY LOW LOW ARBITRARY LOG10 VALUE IS ASSIGNED TO ANY CHANGE
C     WHICH IS 0 OR NEGATIVE ACCORDING TO THE FUNCTION. (NOT POSSIBLE
C     PHYSICALLY)
C
   60 DEL=-50.0
      GO TO 70
C
C     LOG10(DEL) IS THE PLOTTED Y VARIABLE FOR A WELL BEHAVED FUNCTION.
C
   65 DEL=ALOG10(DEL)
C
C     XVAL AND YVAL CHECK FOR VALUES OUTSIDE LIMITS OF THE PLOT AND
C     GIVE ANY SUCH POINT A VALUE WHICH WILL PLOT .25 INCHES OUTSIDE
C     THE GRID.
C
   70 XN=XVAL(D1,XMAX,XMIN,XS)
      YN=YVAL(DEL,YMAX,YMIN,YS)
      CALL FPLOT(0,XN,YN)
      CALL SYMBOL(9,.04)
      IF(DEL.LE.-50.0)GO TO 72
C
C     THE CHANGE IS CONVERTED FROM LOG10 VALUE FOR PRINTING.
C
      DEL=10.0**DEL
C
C     WRITE OUT 'SLOT NUMBER', DIAMETER (MICRONS), AND CHANGE IN
C     MASS (OR NUMBER) CONCENTRATION IN MG/DNM3 (OR IN NO./DNM3).
C
      WRITE(3,145)I,DPLOT,DEL
      GO TO 73
C
C     WRITE OUT THE SLOT NUMBER, DIAMETER (MICRONS), AND 'NON-INCREASING'
C     IF FUNCTION INDICATES SUCH. THIS IS A 'FLAG' TO SHOW UNDESIRABLE
C     BEHAVIOR OF THE FITTING FUNCTION.
C
   72 WRITE(3,148)I,DPLOT
C
C     ITERATION CONTINUES USING LARGER AND LARGER DIAMETER VALUES
C     (INCREASE LOG10(1000*DIAMETER) BY DINC) UNTIL DIAMETER IS LARGER
C     THAN DIAMETER CUT POINT OF 1ST STAGE (OR CUT POINT OF CYCLONE).
C
   73 IF(D1.GT.DLDF)GO TO 101
   75 D1=D1+DINC
  100 CONTINUE
C
C     RETURN PEN IN UP POSITION TO BASE Y LINE OF PLOTTER, AND 2 INCHES
C     BEYOND XMAX TO BE READY FOR NEXT PLOT.
C
  101 CONTINUE
      XN=XMAX+4.5/XS
      YN=YMIN-2./YS
      CALL FPLOT(0,XN,YN)
      RETURN
  140 FORMAT(1H1,//,80A1/,1X,'RHO= ',F4.2,' GM/CC'//,51X,'CHANGE IN'/
     1,8X,'INTERVAL',14X,'DIAMETER',9X,'MASS CONCENTRATION'/,
     230X,'(MICRONS)',13X,'(MG/DNM3)'//)
  240 FORMAT(1H1,//,80A1/,1X,'RHO= ',F4.2,' GM/CC'//,51X,'CHANGE IN'/
     1,8X,'INTERVAL',14X,'DIAMETER',8X,'NUMBER CONCENTRATION'/,
     230X,'(MICRONS)',13X,'(NO/DNM3)'//)
  145 FORMAT(11X,I2,4X,2(13X,1PE9.2)/)
  148 FORMAT(11X,I2,17X,1PE9.2,10X,'NON-INCREASING'/)
      END
      SUBROUTINE LABEL (KNT,XS,YS,YMAX,XMIN)
C***********************************************************************
C*
C*    SUBROUTINE LABEL IDENTIFIES THE ORDER OF DATA SETS PLOTTED KNT
C*    WITH THE SYMBOL USED TO DRAW THOSE POINTS, THIS SUBROUTINE IS
C*    CALLED AND THE 'LABEL' WRITTEN ABOVE A GRAPH WHERE MORE THAN 1 SET
C*    OF DATA MAY BE PLOTTED. (NOTE;  KNT IS NOT NECESSARILY THE SAME AS
C*    THE RUN NUMBER OR FILE NUMBER IS AS GIVEN IN THE CALLING
C*    SUBROUTINES WALLY1, WALLY2, AND WALLY3.
C*
C***********************************************************************
C
C
C     KNT - TEST NUMBER CURRENTLY BEING PLOTTED.
C     XS - X SCALE.
C     YS - Y SCALE.
C     YMAX - MAXIMUM VALUE OF THE Y AXIS.
C     XMIN - MINIMUM VALUE OF THE X AXIS.
C
      XCS=.12
      YCS=.12
      LNT=KNT
      IF (KNT-5) 20,20,10
   10 LNT=KNT-5
      YN=YMAX+(.75/YS)
      GO TO 30
   20 YN=YMAX+(1.0/YS)
   30 XN=XMIN+(LNT-1)*(1.25/XS)
      CALL FCHAR (XN,YN,XCS,YCS,0.)
      WRITE(7,1) KNT
    1 FORMAT(1X,'TEST ',I2,'-',2X,',')
      XN=XN+(1.0/XS)
      YN=YN+(0.05/YS)
C
C     THIS SUBROUTINE DRAWS THE SYMBOL USED FOR POINTS ACCORDING TO
C     CODE KNT AT (XN,YN)
C
      CALL PIONT (KNT,XN,YN)
      RETURN
      END
      SUBROUTINE LGLBL(XS,YS,X0,Y0,L,E,K)
C
C  (X0,Y0) ARE THE COORDINATES CORRESPONDING TO THE FIRST LOG CYCLE TO
C   BE IDENTIFIED.
C  PEN MAY BE UP OR DOWN
C  THE IDENTIFICATION IS TO THE LEFT OF THE Y-AXIS
C
C  XS = X-SCALE FACTOR, INCHES/USER'S UNITS
C  YS = Y-SCALE FACTOR, INCHES/USER'S UNITS
C  X0 = INITIAL X-VALUE.
C  Y0 = INITIAL Y-VALUE.
C  L = NUMBER OF LOG10 CYCLES
C  E = EXPONENT OF FIRST CYCLE +,0,-
C  K = 0 FOR LABELING ON RIGHT SIDE OF Y AXIS
C  K = 1 FOR LABELING ON LEFT SIDE OF Y AXIS
C
    1 FORMAT(' 10')
    2 FORMAT(1X,I3)
C
      XK=X0+0.1/XS
      XXK=X0-0.4/XS
      L=L+1
      YY=Y0-0.075/YS
      DO 100 I=1,L
      X=I-1
      YN=X+YY
      X=E+X
      IYN=X
C
      IF(ABS(X)-10.0)20,10,10
C
   10 F=0.2
      GO TO 30
   20 F=0.1
C
   30 IF(IYN) 40,50,50
C
   40 F=F+0.1
   50 IF(K) 55,60,55
   55 XK=X0-(0.4+F)/XS
   60 CALL FCHAR(XK,YN,0.15,0.15,0.0)
      WRITE(7,1)
      YNE=YN+0.1/YS
      IF(K)80,70,80
   70 XXK=XK+F/XS
   80 CALL FCHAR(XXK,YNE,0.1,0.1,0.0)
      WRITE(7,2) IYN
  100 CONTINUE
      L=L-1
C
      RETURN
      END
    60 CARDS ON TAPE
STOP  000000
```

```
      SUBROUTINE MEAN
C
C       THIS SUBROUTINE CALCULATES THE MOLECULAR MEAN FREE PATH AT EACH
C       STAGE JET IN CENTIMETERS.
C
C
      REAL MM,MU,L(8)
      COMMON/BLOCK1/PS(8),MU
      COMMON/BLOCK2/TKI,MM,L
      COMMON/BLOCK5/NCUM
      BZ=1.38E-16*3.14159
      DO 30 I=1,NCUM
      L(I)=(2.0*MU/(PS(I)*1.01325E06))*(SQRT((BZ*TKI*602.3E21)/(8*MM)))
   30 CONTINUE
       RETURN
      END
      SUBROUTINE NDTRI( P,X,D,IE )
C     COPIED FROM IBM 360 SCIENTIFIC SUBROUTINE PACKAGE
      IE = 0
      X =.9999E+74
      D = X
      IF (P) 1,4,2
    1 IE = -1
      GO TO 12
    2 IF (P-1.0) 7,5,1
    4 X = -.99999E+74
    5 D = 0.0
      GO TO 12
    7 D = P
      IF (D-0.5) 9,9,8
    8 D = 1.0-D
    9 T2 = ALOG(1.0/(D*D))
      T = SQRT(T2)
      X = T-( 2.515517+0.802853*T+0.010328*T2)/(1.0+1.432788*T+0.189269*
     1  T2+0.001308*T*T2)
      IF (P-0.5) 10,10,11
   10 X = -X
   11 D = 0.3989423*EXP(-X*X/2.0)
   12 RETURN
      END
      SUBROUTINE PIONT (KNT,XN,YN)
C***********************************************************************
C*
C*    SUBROUTINE PIONT DRAWS DIFFERENT POINTS FOR EACH RUN OF AN
C*    IMPACTOR, IT CAN DRAW 10 DIFFERENT POINT SYMBOLS, I.E. 0 < KNT < 11.
C*
C***********************************************************************
C
C     KNT IS THE TEST NUMBER THAT IS BEING RUN.
C     XN IS THE X POSITION OF THE POINT BEING PLOTED
C     YN IS THE Y POSITION OF THE POINT BEING PLOTED.
C
C     MOVE PEN TO POINT (XN,YN) AND LOWER PEN WITH THIS CALL TO
C
      CALL FPLOT(0,XN,YN)
C
C     GO TO THE LOCATION FOR DESIRED SYMBOL, EACH LOCATION USES A CALL
C     TO PLOTTER SUBROUTINE POINT(N) WHICH CAN DRAW +, X, SQUARE, OR
C     CIRCLE FOR N = 0,1,2, OR 3 RESPECTIVELY. COMBINATIONS OF THESE ARE
C     ALSO USED ALONG WITH OTHER PEN MOVEMENT COMMANDS TO DRAW 10
C     DIFFERENT SYMBOLS.
C
      GO TO (1,2,3,4,5,6,7,8,9,10),KNT
C
C     THE FIRST RUN HAS THE SYMBOL OF A SQUARE.
C
    1 CALL SYMBOL(1,.10)
      RETURN
C
C     THE SECOND RUN HAS THE SYMBOL OF A TRIANGLE.
C
    2 CALL SYMBOL(2,.10)
      RETURN
C
C     THE THIRD RUN HAS THE SYMBOL OF A CIRCLE.
C
    3 CALL SYMBOL(3,.10)
      RETURN
C
C     THE FOURTH RUN HAS THE SYMBOL OF +.
C
    4 CALL SYMBOL(4,.10)
      RETURN
C
C     THE FIFTH RUN HAS THE SYMBOL OF X.
C
    5 CALL SYMBOL(5,.10)
      RETURN
C
C     THE SIXTH RUN HAS THE SYMBOL OF *.
C
    6 CALL SYMBOL(6,.10)
      RETURN
C
C     THE SEVENTH RUN HAS THE SYMBOL OF A SQUARE WITH A X.
C
    7 CALL SYMBOL(1,.10)
      CALL SYMBOL(5,.10)
      RETURN
```

```
C
C     THE EIGHTH RUN HAS THE SYMBOL OF A SQUARE WITH A +.
C
    8 CALL SYMBOL(1,.10)
      CALL SYMBOL(4,.10)
      RETURN
C
C     THE NINTH RUN HAS THE SYMBOL OF A CIRCLE WITH A X.
C
    9 CALL SYMBOL(3,.10)
      CALL SYMBOL(5,.10)
      RETURN
C
C     THE TENTH RUN HAS THE SYMBOL OF A CIRCLE WITH A +.
C
   10 CALL SYMBOL(3,.10)
      CALL SYMBOL(4,.10)
      RETURN
C
C     ANY NUMBER OF SYMBOL  OF THE ABOVE CAN BE USED FOR DATA POINTS,
C     ALSO ANY SYMBOL FROM THE CARD PUNCH CAN ALSO BE USED TO SHOW A
C     DATA POINT.
C
      END
      SUBROUTINE SIMQ(A,B,N,KS)
      DIMENSION A(1),B(1)
C        FORWARD SOLUTION
      TOL=0.0
      KS=0
      JJ=-N
      DO 65 J=1,N
      JY=J+1
      JJ=JJ+N+1
      BIGA=0
      IT=JJ-J
      DO 30 I=J,N
C        SEARCH FOR MAXIMUM COEFFICIENT IN COLUMN
      IJ=IT+I
      IF(ABS(BIGA)-ABS(A(IJ))) 20,30,30
   20 BIGA=A(IJ)
      IMAX=I
   30 CONTINUE
C        TEST FOR PIVOT LESS THAN TOLERANCE (SINGULAR MATRIX)
      IF(ABS(BIGA)-TOL) 35,35,40
   35 KS=1
      RETURN
C        INTERCHANGE ROWS IF NECESSARY
   40 I1=J+N*(J-2)
      IT=IMAX-J
      DO 50 K=J,N
      I1=I1+N
      I2=I1+IT
      SAVE=A(I1)
      A(I1)=A(I2)
      A(I2)=SAVE
C        DIVIDE EQUATION BY LEADING COEFFICIENT
   50 A(I1)=A(I1)/BIGA
      SAVE=B(IMAX)
      B(IMAX)=B(J)
      B(J)=SAVE/BIGA
C        ELIMINATE NEXT VARIABLE
      IF(J-N) 55,70,55
   55 IQS=N*(J-1)
      DO 65 IX=JY,N
      IXJ=IQS+IX
      IT=J-IX
      DO 60 JX=JY,N
      IXJX=N*(JX-1)+IX
      JJX=IXJX+IT
   60 A(IXJX)=A(IXJX)-(A(IXJ)*A(JJX))
   65 B(IX)=B(IX)-(B(J)*A(IXJ))
C        BACK SOLUTION
   70 NY=N-1
      IT=N*N
      DO 80 J=1,NY
      IA=IT-J
      IB=N-J
      IC=N
      DO 80 K=1,J
      B(IB)=B(IB)-A(IA)*B(IC)
      IA=IA-N
   80 IC=IC-1
      RETURN
      END                                                               SIMQ  60
      FUNCTION SLIM(MAXMIN,ALIMIT)
C*****************************************************************************
C*
C*    FUNCTION SLIM FINDS THE MAXIMUM OR MINIMUM LIMITS OF A GRID.
C*
C*    MAXMIN = 0 IF SLIM IS TO FIND THE MINIMUM LIMIT.
C*    MAXMIN = 1 IF SLIM IS TO FIND THE MAXIMUM LIMIT.
C*
C*    ALIMIT = THE SMALLEST VALUE TO BE PLOTTED IF MAXMIN = 0,
C*    ALIMIT = THE LARGEST VALUE TO BE PLOTTED IF MAXMIN = 1
C*
C*    FOR EXAMPLE SLIM(0,-1.2) WOULD RETURN SLIM = -2.0 .
C*    SLIM(1,3.4) WOULD RETURN SLIM = 4.0.
C*
C*****************************************************************************
      LIMIT=ALIMIT
      DIFF=ALIMIT-LIMIT
C
      IF(MAXMIN)1,1,2
    1 IF(DIFF)3,5,5
    2 IF(DIFF)5,5,4
C
C
C     ALIMIT IS A NEGATIVE REAL AND LOOKING FOR A MINIMUM.
C
    3 SLIM=LIMIT-1
      GO TO 6
C
C     ALIMIT IS A POSITIVE REAL AND LOOKING FOR A MAXIMUM.
C
    4 SLIM=LIMIT+1
      GO TO 6
C
C     ALIMIT IS AN INTEGER AND LOOKING FOR EITHER A MAXIMUM OR A MINIMUM;
C     ALIMIT IS NEGATIVE REAL AND LOOKING FOR A MAXIMUM;
C     OR ALIMIT IS A POSITIVE REAL AND LOOKING FOR A MINIMUM.
C
    5 SLIM=LIMIT
C
    6 RETURN
      END
      SUBROUTINE STAGE
C
C
C       THIS SUBROUTINE CALCULATES THE PRESSURE AT EACH STAGE.
C
C
      REAL MU
      COMMON/BLOCK1/PS(8),MU,POA,DPA,TCI,FG(5),DELP(8,4)
      COMMON/BLOCK5/NCUM,MPACTY
      DO 10 I=1,NCUM
      PS(I)=POA-DELP(I,MPACTY)*DPA
   10 CONTINUE
      RETURN
      END
      SUBROUTINE STATPT(NDK1,NOCON,DPLOT,BVD,DLU,DLL,XMAX,XMIN,YMAX,
     1YMIN,XS,YS)
C****************************************************************************
C*
C*
C*    SUBROUTINE STATPT PLOTS A POINT AVD ALONG WITH ITS CONFIDENCE
C*    LIMITS CLU AND CLL VS. DPLOT ON LOG10 SCALE IF NDK1 = 0
C*    OR ON NORMAL PROBABILITY SCALE IF NDK1 = 1. IT PLOTS AVD
C*    ONLY IF NOCON = 1.
C*
C*
C****************************************************************************
C
      AVD=BVD
      CLU=DLU
      CLL=DLL
C
C     IF NDK1 = 0, LOG10 OF DPLOT, CLU, AVD, AND CLL ARE TAKEN
C     IN ORDER TO PLOT.
C     IF NDK1 = 1, DPLOT COMES INTO SUBROUTINE STATPT ALREADY AS
C     LOG10 OF DIAMETER. THE PLOTTED Y VALUES AT THIS DIAMETER (CLU,
C     AVD, AND CLL) MUST BE FOUND BY SUBROUTINE NDTRI WHICH CHANGES
C     THE VALUE TO ITS NORMAL PROBABILITY SCALE EQUIVALENT,YV.
C
      IF(NDK1.EQ.1)GO TO 112
      IF(NOCON.EQ.1)GO TO 108
C
C     IF DPLOT, CLL, AVD, AND/OR CLU < OR = 0.0, THAT VARIABLE(S) SET
C     = -50.0 INSTEAD OF TAKING LOG10.
C
      IF(CLU)101,101,102
  101 CLU=-50.0
      GO TO 105
  102 CLU=ALOG10(CLU)
  105 IF(CLL)106,106,107
  106 CLL=-50.0
      GO TO 108
  107 CLL=ALOG10(CLL)
  108 IF(AVD)109,109,111
  109 AVD=-50.0
      GO TO 1111
  111 AVD=ALOG10(AVD)
 1111 DPLOT=ALOG10(DPLOT)
C
C     FUNCTIONS XVAL AND YVAL GIVE THE PLOTTED VARIABLE A
C     VALUE JUST OUTSIDE THE PLOT GRID IF IT EXCEEDS
C     PLOTTING LIMITS. OTHERWISE THE VALUE IS UNCHANGED.
C
  112 XN=XVAL(DPLOT,XMAX,XMIN,XS)-.03/XS
C
C     IF NOCON = 0, PLOT AVERAGE AND CONFIDENCE LIMITS CLL AND CLU.
C     IF NOCON = 1, PLOT ONLY AVERAGE VALUE AVD.
C
      IF(NOCON.EQ.1)GO TO 408
C
C     THIS SECTION FINDS VALUE OF UPPER CONFIDENCE LIMIT
C     CLU ACCORDING TO SCALE USED AND DRAWS A BAR.
C
      IF(NDK1.EQ.0)GO TO 405
```

```
C
C     IF CLL > .9999, SET YV = ARBITRARY NUMBER > YMAX.
C
      IF(CLL-.9999)510,510,505
  505 YV=4.0
      GO TO 406
C
C     IF CLL < .0001, SET YV = ARBITRARY NUMBER < .0001.
C
  510 IF(.0001-CLL)520,520,515
  515 YV=-4.0
      GO TO 406
  520 CALL NDTRI(CLL,YV,D,IE)
      GO TO 406
  405 YV=CLL
  406 YN=YVAL(YV,YMAX,YMIN,YS)
      CALL FPLOT(-2,XN,YN)
      XN=XN+.06/XS
      CALL FPLOT(0,XN,YN)
      XN=XN-.03/XS
      CALL FPLOT(0,XN,YN)
C
C     THIS SECTION FINDS VALUE OF AVERAGE ACCORDING TO
C     SCALE USED, DRAWS LINE FROM CLL DOWN TO THAT POINT,
C     AND DRAWS CIRCLE. NOTE - IF NOCON = 1, ONLY THIS
C     CIRCLE IS DRAWN (WITHOUT CONFIDENCE LIMITS).
C
  408 IF(NDK1.EQ.0)GO TO 410
      IF(AVD-.9999)560,560,555
  555 YV=4.0
      GO TO 411
  560 IF(.0001-AVD)570,570,565
  565 YV=-4.0
      GO TO 411
  570 CALL NDTRI(AVD,YV,D,IE)
      GO TO 411
  410 YV=AVD
  411 YN=YVAL(YV,YMAX,YMIN,YS)
      CALL FPLOT(0,XN,YN)
      CALL SYMBOL(9,.04)
      IF(NOCON.EQ.1)GO TO 417
C
C     THIS SECTION FINDS VALUE OF LOWER CONFIDENCE LIMIT
C     CLL ACCORDING TO SCALE USED, DRAWS LINE FROM AVD TO THAT POINT,
C     AND DRAWS A BAR.
C
      IF(NDK1.EQ.0)GO TO 415
      IF(CLU-.9999)580,580,575
  575 YV=4.0
      GO TO 416
  580 IF(.0001-CLU)590,590,585
  585 YV=-4.0
      GO TO 416
  590 CALL NDTRI(CLU,YV,D,IE)
      GO TO 416
  415 YV=CLU
  416 YN=YVAL(YV,YMAX,YMIN,YS)
      CALL FPLOT(0,XN,YN)
      XN=XN-.03/XS
      CALL FPLOT(0,XN,YN)
      XN=XN+.06/XS
C     RAISE THE PEN, MAKING IT READY TO GO TO POINT CORRESPONDING TO
C     NEXT SIZE DIAMETER.
  417 CALL FPLOT(-1,XN,YN)
      RETURN
      END
      SUBROUTINE STPLOT(IDALL,RHO,IMPAC,NDK,PDMAX,PDMIN,DXMAX,DXMIN,
     1ISIZ,XS,YS,XMAX,XMIN,YMAX,YMIN)
C***********************************************************************
C*
C*    SUBROUTINE STPLOT MAKES THE FOLLOWING GRID FOR GIVEN
C*    VALUE OF NDK:
C*         NDK = -1 - AVG. CUMULATIVE MASS LOADING (IN MG/ACM
C*                    ON LEFT AXIS, IN GR/ACF ON RIGHT AXIS)
C*         NDK =  0 - AVG. DM/DLOGD (IN MG/DNM3)
C*         NDK =  1 - AVG. DN/DLOGD (IN NO/DNM3)
C*    ALL OF THE ABOVE PLOTS SHOW PARTICLE DIAMETER (MICRONS)
C*   ALONG THE ABCISSA.
C*    THE GENERAL IDENTIFICATION LABEL ID AND DENSITY RHO
C*    ARE PRINTED ABOVE THE GRID.
C*
C***********************************************************************
C
      DIMENSION IDALL(80),PDMAX(2),PDMIN(2),DXMAX(2),DXMIN(2)
      DATA IBLK/' '/
C
C
      PI=3.1415
      M=7
      N=1
      IF(RHO.EQ.1.0)N=2
C
C     XIN - LENGTH OF THE X AXIS IN INCHES.
C     YIN - LENGTH OF THE Y AXIS IN INCHES.
C
      XIN=4.5
      YIN=6.5
C
C
C     THIS SECTION FINDS XMAX,YMAX,YMIN,AND YMIN WHERE:
C     XMAX - MAXIMUM X VALUE PLOTTED.
C     YMAX - MAXIMUM Y VALUE PLOTTED.
C     XMIN - MINIMUM X VALUE PLOTTED
C     YMIN - MINIMUM Y VALUE PLOTTED.
C
C     IF ISIZ = 1 - THE MAXIMUM AND MINIMUM DIAMETERS, GEMAX AND
C          GEMIN, ARE USED TO GET XMAX AND XMIN, ALSO MAXIMUM AND MINIMUM
C          ORDINATE VALUES, DXMAX AND DXMIN, ARE USED TO GET YMAX AND YMIN.
C    IF ISIZ = 0 - XMAX = LOG10(100 MICRONS)
C                  XMIN = LOG10(.25 MICRONS)
C                  YMAX,YMIN - DEPEND ON IMPACTOR USED (I.E. IMPAC)
C                  IMPAC = 1 - ANDERSEN
C                        = 2 - BRINK
C                        = 3 - PILAT
C                        = 4 - MRI
      IF(ISIZ.EQ.1)GO TO 25
      IF(NDK)21,22,24
   21 YMAX=10000.
      YMIN=.1
      GO TO 23
   22 GO TO (221,222,221,221),IMPAC
  221 YMAX=1.0E04
      YMIN=1.0E-02
      GO TO 23
  222 YMAX=1.0E06
```

```
      YMIN=1.0
      GO TO 23
   24 GO TO (240,241,240,240),IMPAC
  240 YMAX=1.0E15
      YMIN=1.0E06
      GO TO 23
  241 YMAX=1.0E14
      YMIN=1.0E05
   23 XMAX=ALOG10(100.0)
      YMAX=ALOG10(YMAX)
      XMIN=ALOG10(.1)
      YMIN=ALOG10(YMIN)
      GO TO 28
   25 XMAX=SLIM(1,ALOG10(100.0))
      YMAX=SLIM(1,ALOG10(DXMAX(N)))
      XMIN=SLIM(0,ALOG10(PDMIN(N)))
      YMIN=SLIM(0,ALOG10(DXMIN(N)))
C
C     X AND Y SCALE FACTORS CALCULATED HERE.
C
   28 XS=XIN/(XMAX-XMIN)
      YS=YIN/(YMAX-YMIN)
      YO=YMIN-2./YS
      CALL SCALF (XS,YS,XMIN,YO)
C
C     DRAW THE X - AXIS.
C
      YMIN1=YMIN
      IXRAN=XMAX-XMIN
      CALL XSLBL(XS,YS,XMIN,YMIN1,IXRAN,XMIN)
      CALL XLOG(XS,YS,XMAX,YMIN1,-1,IXRAN)
C
C     LABEL THE X - AXIS.
C     XCS AND YCS ARE THE DIMENSIONS OF WRITTEN CHARACTERS IN INCHES.
C
      XCS=.15
      YCS=.15
      X=((XMAX-XMIN)/2.0)+XMIN-(16.0*XCS)/XS
      Y=YMIN1-(.7/YS)
      CALL FCHAR (X,Y,XCS,YCS,0.)
C
C     WRITE 'PARTICLE DIAMETER (MICROMETERS)' BELOW ABSCISSA.
C
      WRITE(M,1)
C
C     WRITE THE ID LABELS.
C
      XCS=.056
      YCS=.100
      X=XMIN
      Y=YMAX+.5/YS
C
C     THIS DO LOOP FINDS LAST CHARACTER IN IDENTIFICATION
C     LABEL. (SAVES PEN MOVEMENT IF LESS THAN 80 CHARACTERS)
C
      DO 30 I=1,79
      J=80-I
      IF(IDALL(J).NE.IBLK)GO TO 40
   30 CONTINUE
      J=1
   40 CALL FCHAR (X,Y,XCS,YCS,0.)
C
C     WRITE THE IDENTIFICATION LABEL ABOVE GRAPH
C
      WRITE(M,2)(IDALL(I),I=1,J)
      X=XMIN
      Y=YMAX+.25/YS
      CALL FCHAR (X,Y,XCS,YCS,0.)
C
C     WRITE THE DENSITY RHO (GM/CC) ABOVE THE GRAPH.
C
      WRITE(M,5) RHO
C
C     DRAW THE Y - AXIS ON THE LEFT SIDE OF THE GRAPH.
C
      IYMAX=YMAX
      IYMIN=YMIN
      IYRAN=IYMAX-IYMIN
      CALL YLOG(XS,YS,XMIN,YMAX,-1,IYRAN)
      CALL LGLBL(XS,YS,XMIN,YMIN,IYRAN,YMIN,1)
C
C     LABEL THE Y - AXIS ON THE LEFT SIDE OF THE GRAPH.
C
      XCS=.15
      YCS=.15
      X=XMIN-.7/XS
      Y=(YMAX-YMIN)/2.0+YMIN-(16.0*XCS)/YS
      CALL FCHAR(X,Y,XCS,YCS,PI/2.)
C
C     LABEL ORDINATE WITH FOLLOWING ACCORDING TO VALUE OF NDK:
C           NDK = -1 - 'CUMULATIVE MASS LOADING (MG/ACM)'
C               =  0 - 'DM/DLOGD (MG/DNM3)'
C               =  1 - 'DN/DLOGD (NO. PARTICLES/DNM3)'
C     ALSO IF NDK = -1, AN ORDINATE AXIS IS DRAWN ON RIGHT SIDE
C     OF GRAPH FOR 'CUMULATIVE MASS (GR/ACF)'. NOTE - LAST VARIABLE
C     OF LGLBL IS 0 SO THAT NUMBERS WILL BE PRINTED TO RIGHT OF AXIS.
C
      IF(NDK)41,42,43
   41 WRITE(M,12)
      IF(IYRAN.EQ.1)GO TO 60
C     DRAW THE Y - AXIS ON THE RIGHT SIDE OF THE GRAPH.
C
      YO=YMIN+.3595
      YLEF=YMIN-3.
      CALL LGLBL(XS,YS,XMAX,YO,IYRAN,YLEF,0)
      CALL YLOG(XS,YS,XMAX,YMAX+.3595,-1,IYRAN)
C
C     LABEL THE Y - AXIS ON THE RIGHT SIDE OF THE GRAPH.
C
      X=XMAX+.8/XS
      Y=((YMAX+.3595)-YMIN)/2.0+YMIN-(16.*XCS)/YS
      CALL FCHAR (X,Y,XCS,YCS,PI/2.)
      WRITE(M,13)
      GO TO 60
   42 WRITE(M,6)
      GO TO 60
   43 WRITE(M,14)
   60 RETURN
    1 FORMAT(1X,'PARTICLE DIAMETER (MICROMETERS)')
    2 FORMAT(1X,80A1)
```

```
  4 FORMAT(1X,'        DM/DLOGD (MG/DNM3)        ')
  5 FORMAT(1X,'RHO = ',F4.2,' GM/CC')
 12 FORMAT(1X,'CUMULATIVE MASS LOADING (MG/ACM)')
 13 FORMAT(1X,'CUMULATIVE MASS LOADING (GR/ACF)')
 14 FORMAT(1X,'        DN/DLOGD (NO. PARTICLES/DNM3)')
    END
```

```
      SUBROUTINE SYMBOL(KODE,SIZE)
C
C     WRITTEN BY HENRY FINCH FOR CHEMOTHERAPY DIVISION AT SOUTHERN
C     RESEARCH INSTITUTE - NOVEMBER, 1976.
C
C
C  SUB. SYMBOL DRAWS THE FOLLOWING SYMBOL WITH RESPECT TO THE KODE:
C   KODE 1 = A SQUARE
C   KODE 2 = A TRIANGLE
C   KODE 3 = A CIRCLE
C   KODE 4 = A +
C   KODE 5 = A X
C   KODE 6 = A * (A + OVER AN X)
C   KODE 7 = A SOLID SQUARE
C   KODE 8 = A SOLID TRIANGLE
C   KODE 9 = A SOLID CIRCLE
C   KODE 10 = A DIAMOND
C   KODE 11 = A SOLID DIAMOND
C
C   IF KODE < 0 ; OR KODE > 9 SUB. IS RETURNED WITH NO SYMBOL DRAWN
C   THIS SUB LEAVES THE PEN IN SAME POSITION AS WHEN IT WAS CALLED  ALSO ---
C   PEN IS LEFT UP IF PEN WAS UP ;; PEN LEFT DOWN IF PEN WAS DOWN
C
C   SIZE = SIDE (IN INCHES) OF SQUARE INSCRIBING SYMBOL DRAWN
C+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C
      DIMENSION MODE(5),IX(9),IY(9)
      EQUIVALENCE (MODE(1),MODE1),(MODE(2),MODE2),(MODE(3),MODE3),
     $ (MODE(4),MODE4),(MODE(5),MODE5)
      EQUIVALENCE (IX(1),IX1),(IX(2),IX2),(IX(3),IX3),(IX(4),IX4),
     $ (IX(5),IX5),(IX(6),IX6),(IX(7),IX7),(IX(8),IX8),(IY(1),IY1),
     $ (IY(2),IY2),(IY(3),IY3),(IY(4),IY4),(IY(5),IY5),(IY(6),IY6),
     $ (IY(7),IY7),(IY(8),IY8),(IY(9),IY9),(IX(9),IX9)
      DATA MODE/1,2,3,4,5/
      DATA CONST/0.707107/
C
      RND(XX)=XX+SIGN(0.5,XX)
C
      ISZ2=RND(SIZE*100.0/2.0)
      SIZE1=ISZ=ISZ2*2
      IF(KODE.LE.0) RETURN
      IF(KODE.GT.11) RETURN
      IF(ISZ2.LE.0) RETURN
      ISTRT=1
      IX1=IY1=0
      IX6=ISZ2
      IY6=-ISZ2
C
      READ(7)LASTX,LASTY,IX2,IX3,IX4,IX5,IPEN
      GO TO (50,50,40,400,500,600,50,50,40,40,40),KODE
   40 IY6=0
   50 ISTRT=2
      WRITE(7)MODE4,IX6,IY6
      GO TO (100,200,300,400,400,400,100,200,300,350,350),KODE
C
C   THIS SECTION SETS UP FOR THE DRAWING OF A SQUARE
C
  100 IEND=5
      IY1=-IX1
      IY2=IX5=ISZ
      IX3=IY4=-ISZ
      IX2=IY3=IX4=IY5=0
      GO TO 550
C
C   THIS SECTION SETS UP FOR THE DRAWING OF A TRIANGLE
C
  200 IEND=4
      IY1=-IX1
      IY4=IX2=-ISZ
      IY3=ISZ
      IY2=0
      IX3=IX4=ISZ2
      GO TO 550
C
C   THIS SECTION SETS UP & DRAWS A CIRCLE
C   A SOLID CIRCLE IS ALSO DRAWN IN THIS SECTION
C
  300 THETA=0.0
      SIZE2=SIZE1/2.0
      THLAST=6.283185+THETA
      THINC=2.00/SIZE1
  325 IX1=RND(SIZE2*COS(THETA))
      IY1=RND(SIZE2*SIN(THETA))
      IX2=IX1+LASTX
      IY2=IY1+LASTY
      WRITE(7) MODE3,IX2,IY2
      THETA=THETA+THINC
      IF(THETA.LE.THLAST) GO TO 325
      IF(MODE.EQ.3) GO TO 750
      SIZE1=SIZE1-2.0
      IF(SIZE1) 800,300,300
C
C   THIS SECTION IS FOR DRAWING A DIAMOND
C
  350 IEND=9
      IX2=IX3=IX6=IX7=-ISZ2
      IX4=IX5=IX8=IX9=ISZ2
      IY2=IY5=IY7=IY8=-ISZ2
      IY3=IY4=IY6=IY9=ISZ2
      GO TO 550
C
C   THIS SECTION SETS UP FOR THE DRAWING OF A +
C
  400 IEND=8
      IY5=IY6=IY7=IY8=IX1=IX2=IX3=IX4=0
      IY1=IY4=IX5=IX8=-ISZ2
      IY2=IY3=IX6=IX7=ISZ2
      GO TO 550
C
C   THIS SECTION SETS UP FOR THE DRAWING OF AN X
C
  500 IEND=8
      IX1=IY2=IY3=IX4=IX6=IY6=IX7=IY7=ISZ2
      IX2=IY1=IX3=IY4=IY5=IX5=IY8=IX8=-ISZ2
C
C   THIS SECTION ACTUALLY DRAWS ANY DESIGNATED SYMBOL EXCEPT A CIRCLE
C
  550 DO 600 I=ISTR,IEND
      WRITE(7) MODE,IX(I),IY(I)
  600 CONTINUE
      GO TO (750,750,750,800,800,625,640,640,800,750,645),KODE
C
C   THIS SECTION TESTS IY8 TO CHECK IF THE PROG IS THROUGH SUPER IMPOSING A
C   OVER AN X  ***** BE CAREFUL WITH THIS KEY IN CASE OF MODIFICATION ****
C
  625 IF(IY8,EQ,0) GO TO 500
      GO TO 800
C
C   THIS SECTION IS FOR DECREMENTING SIZE PARAMETERS FOR THE DRAWING OF
C     A SOLID SQUARE, A SOLID TRIANGLE, OR A SOLID DIAMOND DEPENDING
C     ON KODE,
C
  640 ISZ=ISZ-1
  645 ISZ=ISZ-1
      IX1=-1
      ISZ2=ISZ2-1
      ISTRT=1
      IF(ISZ,LE,0) GO TO 800
      GO TO (800,800,800,800,800,800,100,200,800,800,350),KODE
  700 I=MODE3
      IPEN=-1
      GO TO 775
  725 IPEN=-1
  750 I=MODE2
  775 WRITE(7)I,LASTX,LASTY
  800 IF(IPEN)850,725,700
  850 RETURN
      END
      SUBROUTINE VIS
C       THIS SUBROUTINE CALCULATES THE VISCOSITY OF THE GAS USING
C       A METHOD PRESENTED BY C, R, WILKE IN A PAPER ENTITLED
C       "A VISCOSITY EQUATION FOR GAS MIXTURES" IN THE JOURNAL OF
C       CHEMICAL PHYSICS  VOLUME 8, NUMBER 4, APRIL 1950, PAGE 517.
C
C
C
C
      REAL MU
      DIMENSION WT(5),VS(5)
      COMMON/BLOCK1/PS(8),MU,POA,DPA,TCI,FG(5)
C
C       WT(I) ARE THE MOLECULAR WEIGHTS OF CO2,CO,N2,O2,H2O,
C
      DATA WT/44.10,28.01,28.02,32.00,18.02/
C
C       VS(I) ARE THE PURE GAS VISCOSITIES OF CO2,CO,N2,O2,H2O.
C
      VS(1)=138,494+0,499*TCI-0,267E-03*TCI*TCI+0,972E-07*TCI*TCI*TCI
      VS(2)=165,763+0,442*TCI-0,213E-03*TCI*TCI
      VS(3)=167,086+0,417*TCI-0,139E-03*TCI*TCI
      VS(4)=190,187+0,558*TCI-0,336E-03*TCI*TCI+0,139E-06*TCI*TCI*TCI
      VS(5)=87,800+0,374*TCI+0,238E-04*TCI*TCI
      DO 10 I=1,5
   10 VS(I)=VS(I)*1,0E-06
      MU=0,0
      DO 200 I=1,5
      IF(FG(I)-0,0) 200,199,200
  199 FG(I)=1,0E-20
  200 CONTINUE
      DO 300 I=1,5
      XPHEE1=0,0
      XPHEE=0,0
      PHEE=0,0
      DO 400 J=1,5
      XPHEE=((1,0+(SQRT(VS(I)/VS(J)))*((WT(J)/WT(I))**0,25))**2,0)/((4,0
     1/1,414)*(SQRT(1,0+(WT(I)/WT(J)))))
      XPHEE1=FG(J)*XPHEE
      IF(J-I) 399,400,399
  399 PHEE=PHEE+XPHEE1
  400 CONTINUE
      PHEE=PHEE/FG(I)+1,0
      MU=MU+VS(I)/PHEE
  300 CONTINUE
C
C       THE FINAL VISCOSITY MU IS IN POISE.
C
      RETURN
      END
      SUBROUTINE WALLY1
C*****************************************************************************
C*
C*    THIS SUBROUTINE DRAWS NEW GRID (IF MPLOT > 0) AND MAKES A PLOT OF
C*    CUMULATIVE MASS LOADING (MG/ACM) VS. D50 (MICRONS) ON A LOG10 VS.
C*    LOG10 GRID. ALSO WALLY1 CALLS SUBROUTINE JOE1 TO SUPERIMPOSE FIT IF
C*    ISIG > 0 (NEW GRID ALWAYS DRAWN IN THIS CASE).
C*
C*****************************************************************************
C
      INTEGER VV
      DOUBLE PRECISION XNOPEN(10),YO(10)
      DIMENSION IDALL(80),GEMAX(2),GEMIN(2),DMMAX(2),DMMIN(2),DNMAX(2)
      DIMENSION DNMIN(2),DPMAX(2),DPMIN(2),CUMAX(2),CUMIN(2),ID(80)
      DIMENSION DPC(8),CUMG(8),DMDLD(9),GEOMD(9),DNDLD(9)
      COMMON IMPAC,IDALL,RHO1,GEMAX,GEMIN,DMMAX,DMMIN,DNMAX,DNMIN
      COMMON DPMAX,DPMIN,CUMAX,CUMIN,ISIZ1,ISIZ2,ISIZ3
      COMMON IS,NFIT,ID,RHO,DMIN,TKS,PDA,FG(5),DMAX,DPC,CUMG,DMDLD
      COMMON GEOMD,DNDLD,GRNAM,MPLOT,DSMA,VV
      COMMON ISIG,XMAX,XMIN,YMAX,YMIN,XS,YS
      COMMON CYC3,MC3,MOO,MS
      COMMON XNOPEN
      DATA IBLK/' '/
C
      PI=3.1415
C
C     M IS CODING FOR OUTPUT DEVICE. HERE M = 7 FOR PLOTTER.
C
      M=7
C
C     FOR ASSUMED PHYSICAL DENSITY, N = 1 TO READ FROM ODD NUMBERED
C     RECORDS. FOR ASSUMED AERODYNAMIC DENSITY, N = 2 TO READ FROM EVEN
C     NUMBERED RECORDS.
C
      N=1
      IF(RHO.EQ.1.0)N=2
C
C     THE SAME GRID AS PREVIOUS PLOT. NEW GRID ALWAYS DRAWN IF ISIG = 0
C     (JOE1 TO BE CALLED.).
C
      IF(ISIG.EQ.1)GO TO 20
      IF(MPLOT) 80,80,20
C
C     XIN = LENGTH OF THE X AXIS IN INCHES.
C     YIN = LENGTH OF THE Y AXIS IN INCHES.
C
   20 KNT=0
      XIN=6.5
      YIN=6.5
C
C     XMAX = MAXIMUM X VALUE PLOTTED.
C     YMAX = MAXIMUM Y VALUE PLOTTED.
C     XMIN = MINIMUM X VALUE PLOTTED
C     YMIN = MINIMUM Y VALUE PLOTTED.
C
C
      IF(ISIZ1.EQ.1)GO TO 25
      XMAX=ALOG10(100.0)
      YMAX=ALOG10(10000.0)
      XMIN=ALOG10(.1)
      YMIN=ALOG10(.1)
      GO TO 28
   25 XMAX=2.0
      YMAX=SLIM(1,ALOG10(CUMAX(N)))
      XMIN=SLIM(0,ALOG10(DPMIN(N)))
      YMIN=SLIM(0,ALOG10(CUMIN(N)))
C     X AND Y SCALE FACTORS CALCULATED HERE.
C
   28 XS=XIN/(XMAX-XMIN)
      YS=YIN/(YMAX-YMIN)
      YORIG=YMIN-2./YS
      CALL SCALF(XS,YS,XMIN,YORIG)
C
C     DRAW THE X - AXIS.
C
      YMIN1=YMIN
      IXMAX=XMAX
      IXMIN=XMIN
      IXRAN=IXMAX-IXMIN
      CALL XSLBL(XS,YS,XMIN,YMIN1,IXRAN,XMIN)
      CALL XLOG(XS,YS,XMAX,YMIN1,-1,IXRAN)
C
C     LABEL THE X - AXIS.
C
      XCS=.15
      YCS=.15
      X=((XMAX-XMIN)/2.0)+XMIN-(16.0*XCS)/XS
      Y=YMIN1-(.7/YS)
      CALL FCHAR (X,Y,XCS,YCS,0.)
      WRITE(M,1)
C
C     DRAW THE Y - AXIS ON THE RIGHT SIDE OF THE GRAPH.
      Y0=YMIN1+.3595
      IYMAX=YMAX
      IYMIN=YMIN
      IYRAN=IYMAX-IYMIN
      IF(IYRAN.EQ.1)GO TO 29
      YLEF1=YMIN1-3.0
      CALL LGLBL(XS,YS,XMAX,Y0,IYRAN,YLEF1,0)
      CALL YLOG(XS,YS,XMAX,YMAX+.3595,-1,IYRAN)
C
C     LABEL THE Y - AXIS ON THE RIGHT SIDE OF THE GRAPH.
C
      X=XMAX+.8/XS
      Y=((YMAX+.3595)-YMIN1)/2.0+YMIN1-(16.*XCS)/YS
      CALL FCHAR (X,Y,XCS,YCS,PI/2.)
      WRITE(M,3)
C
C     WRITE THE ID LABELS.
C
   29 XCS=.056
      YCS=.100
      X=XMIN
      Y=YMAX+.5/YS
      DO 30 I=1,79
      J=80-I
      IF(ID(J).NE.IBLK) GO TO 40
   30 CONTINUE
      J=1
   40 CALL FCHAR (X,Y,XCS,YCS,0.)
      WRITE(M,2) (ID(I),I=1,J)
      X=XMIN
      Y=YMAX+.25/YS
      CALL FCHAR (X,Y,XCS,YCS,0.)
      WRITE(M,5) RHO
C
C     DRAW THE Y - AXIS ON THE LEFT SIDE OF THE GRAPH.
C
      CALL YLOG(XS,YS,XMIN,YMAX,-1,IYRAN)
      CALL LGLBL(XS,YS,XMIN,YMIN,IYRAN,YMIN,1)
C
C     LABEL THE Y - AXIS ON THE LEFT SIDE OF THE GRAPH.
C
      XCS=.15
      YCS=.15
      X=XMIN-.7/XS
      Y=(YMAX-YMIN)/2.0+YMIN-(16.0*XCS)/YS
      CALL FCHAR(X,Y,XCS,YCS,PI/2.)
      WRITE(M,4)
C
C     PLOT X AND Y VALUES FOR CUMULATIVE MASS LOADING (MG/ACM) VS. D50
C     (MICROMETERS).
C
C
C     FIRST PLOT TOTAL MASS LOADING VS. MAXIMUM PARTICLE DIAMETER.
C
   80 KNT=KNT+1
      X1=ALOG10(DMAX)
      XN=XVAL(X1,XMAX,XMIN,XS)
      Y1=ALOG10(GRNAM)
      YN=YVAL(Y1,YMAX,YMIN,YS)
      CALL PIONT (KNT,XN,YN)
C
C     PLOTTING FOR BRINK IMPACTOR HANDLED SEPERATELY DUE TO VARIATION
C     IN CONFIGURATION USED. STATEMENTS 80 - 200 APPLY TO THE BRINK
C     IMPACTOR (IMPAC = 2).
C
      GO TO (200,181,200,200),IMPAC
  181 IF(MC3)82,82,81
   81 X2=ALOG10(CYC3)
      XN=XVAL(X2,XMAX,XMIN,XS)
      Y2=ALOG10(CUMG(1))
      YN=YVAL(Y2,YMAX,YMIN,YS)
      CALL PIONT (KNT,XN,YN)
      M=7
      IF(MS.LT.6)M=6
      DO 70 J=1,M
      IF(DPC(J)-CUMG(J+1))70,70,90
   90 XNEX=ALOG10(DPC(J))
      XN=XVAL(XNEX,XMAX,XMIN,XS)
      YNEX=ALOG10(CUMG(J+1))
      YN=YVAL(YNEX,YMAX,YMIN,YS)
      CALL PIONT (KNT,XN,YN)
   70 CONTINUE
      GO TO 77
   82 IF(M00)84,84,83
   83 M=7
      IF(MS.LT.6)M=6
      DO 75 J=1,M
      IF(DPC(J)*CUMG(J))75,75,191
  191 XNEX=ALOG10(DPC(J))
      XN=XVAL(XNEX,XMAX,XMIN,XS)
      YNEX=ALOG10(CUMG(J))
      YN=YVAL(YNEX,YMAX,YMIN,YS)
      CALL PIONT (KNT,XN,YN)
   75 CONTINUE
      GO TO 77
   84 M=6
      IF(MS.LT.6)M=5
      DO 77 J=1,M
      IF(DPC(J+1)*CUMG(J))77,77,92
   92 XNEX=ALOG10(DPC(J+1))
      XN=XVAL(XNEX,XMAX,XMIN,XS)
      YNEX=ALOG10(CUMG(J))
      YN=YVAL(YNEX,YMAX,YMIN,YS)
      CALL PIONT (KNT,XN,YN)
   77 CONTINUE
      GO TO 300
C
C     THIS LOOP PLOTS CUMULATIVE MASS LOADING VS. D50 FOR ANDERSEN
C     (IMPAC = 1), U. OF W. (IMPAC = 3), OR MRI IMPACTOR (IMPAC = 4).
C
  200 DO 175 J=1,VV
      IF(DPC(J)*CUMG(J))175,175,91
   91 XNEX=ALOG10(DPC(J))
      XN=XVAL(XNEX,XMAX,XMIN,XS)
      YNEX=ALOG10(CUMG(J))
      YN=YVAL(YNEX,YMAX,YMIN,YS)
      CALL PIONT(KNT,XN,YN)
  175 CONTINUE
  300 IF(ISIG)130,130,150
C
C     CALL SUBROUTINE JOE1 TO SUPERIMPOSE FITTED CURVE IF DESIRED (ISIG
C     > 0).
C
  150 CALL JOE1
      RETURN
C
  130 CONTINUE
C
C     THIS SUBROUTINE IDENTIFIES THE SET OF DATA PLOTTED WITH THE
C     SYMBOL USED TO DRAW POINTS. (IMPORTANT IF MORE THAN ONE SET OF
C     DATA IS SUPERIMPOSED ON ONE GRID.
C
      CALL LABEL (KNT,XS,YS,YMAX,XMIN)
C
C     RETURN PEN TO *HOME POSITION* AT BASE OF PLOTTER 4.5 INCHES FROM
C     THE MAXIMUM VALUE OF THE X AXIS.. PEN IN THE UP POSITION.
C
      X=XMAX+4.5/XS
      Y=YMIN-2./YS
      CALL PPLOT(+1,X,Y)
      RETURN
    1 FORMAT(1X,*PARTICLE DIAMETER (MICROMETERS)*)
    2 FORMAT(1X,80A1)
    3 FORMAT(1X,*CUMULATIVE MASS LOADING (GR/ACF)*)
    4 FORMAT(1X,*CUMULATIVE MASS LOADING (MG/ACM)*)
    9 FORMAT(1X,*RHO = *,F4.2,* GM/CC*)
      END
   240 CARDS ON TAPE
STOP  000000
```

```
      SUBROUTINE WALLY2
C************************************************************************
C*
C*    SUBROUTINE WALLY2 DRAWS NEW GRID (IF MPLOT > 0) AND MAKES A PLOT OF
C*    CHANGE IN MASS SIZE CONCENTRATION (MG/DNM3) VS. GEOMETRIC MEAN
C*    DIAMETER (MICRONS) ON A LOG10 VS. LOG10 GRID. ALSO, WALLY2 CALLS
C*    SUBROUTINE JOE2 TO SUPERIMPOSE POINTS BASED ON CURVE FITTING IF
C*    ISIG > 0 (NEW GRID ALWAYS DRAWN IN THIS CASE.)
C*
C************************************************************************
C
      INTEGER VV
      DOUBLE PRECISION XNDPEN(10),YO(10)
      DIMENSION IDALL(80),GEMAX(2),GEMIN(2),DMMAX(2),DMMIN(2),DNMAX(2)
      DIMENSION DNMIN(2),DPMAX(2),DPMIN(2),CUMAX(2),CUMIN(2),ID(80)
      DIMENSION DPC(8),CUMG(8),DMDLD(9),GEOMD(9),DNDLD(9)
      COMMON IMPAC,IDALL,RHO1,GEMAX,GEMIN,DMMAX,DMMIN,DNMAX,DNMIN
      COMMON DPMAX,DPMIN,CUMAX,CUMIN,ISIZ1,ISIZ2,ISIZ3
      COMMON IS,NFIT,ID,RHO,DMIN,TKS,POA,FG(5),DMAX,DPC,CUMG,DMDLD
      COMMON GEOMD,DNDLD,GRNAM,MPLOT,DSMA,VV
      COMMON ISIG,XMAX,XMIN,YMAX,YMIN,XS,YS
      COMMON CYC3,MC3,M00,MS
      COMMON XNDPEN
C
      PI=3.1415
C
C     M IS CODING FOR OUTPUT DEVICE, HERE M = 7 FOR PLOTTER.
C
      M=7
C
C     FOR ASSUMED PHYSICAL DENSITY, N = 1 TO READ FROM ODD NUMBERED
C     RECORDS, FOR ASSUMED AERODYNAMIC DENSITY, N = 2 TO READ FROM EVEN
C     NUMBERED RECORDS.
C
      N=1
      IF(RHO.EQ.1.0)N=2
C
C     IF MPLOT=1 PLOT NEW GRID ON EACH PASS THROUGH PROGRAM, IF MPLOT=0
C     THE SAME GRID AS PREVIOUS PLOT, NEW GRID ALWAYS DRAWN IF ISIG > 0
C     (JOE2 TO BE CALLED.).
C
      IF(ISIG.GT.0)GO TO 20
      IF(MPLOT) 80,80,20
C
C     XIN = LENGTH OF THE X AXIS IN INCHES.
C     YIN = LENGTH OF THE Y AXIS IN INCHES.
C
   20 KNT=0
      XIN=4.5
      YIN=6.5
C
C     XMAX = MAXIMUM X VALUE PLOTTED.
C     YMAX = MAXIMUM Y VALUE PLOTTED.
C     XMIN = MINIMUM X VALUE PLOTTED
C     YMIN = MINIMUM Y VALUE PLOTTED.
C
      IF(ISIZ2.EQ.1)GO TO 25
      GO TO (221,222,221,221),IMPAC
  221 YMAX=1.0E04
```

```
      YMIN=,01
      GO TO 23
  222 YMAX=1,0E06
      YMIN=1,0
   23 XMAX=2,0
      YMAX=ALOG10(YMAX)
      XMIN=ALOG10(,1)
      YMIN=ALOG10(YMIN)
      GO TO 28
   25 XMAX=2,0
      YMAX=SLIM(1,ALOG10(DMMAX(N)))
      XMIN=SLIM(0,ALOG10(GEMIN(N)))
      YMIN=SLIM(0,ALOG10(DMMIN(N)))
C
C     X AND Y SCALE FACTORS CALCULATED HERE,
C
   28 XS=XIN/(XMAX-XMIN)
      YS=YIN/(YMAX-YMIN)
      YORIG=YMIN-2,/YS
      CALL SCALF(XS,YS,XMIN,YORIG)
C
C     DRAW THE X - AXIS,
C
      YMIN1=YMIN
      IXMAX=XMAX
      IXMIN=XMIN
      IXRAN=IXMAX-IXMIN
      CALL XBLBL(XS,YS,XMIN,YMIN1,IXRAN,XMIN)
      CALL XLOG(XS,YS,XMAX,YMIN1,-1,IXRAN)
C
C     LABEL THE X - AXIS,
C
      XCS=,15
      YCS=,15
      X=((XMAX-XMIN)/2,0)+XMIN-(16,0*XCS)/XS
      Y=YMIN1-(,7/YS)
      CALL FCHAR (X,Y,XCS,YCS,0,)
      WRITE(M,1)
C
C     WRITE THE ID LABELS,
C
      XCS=,056
      YCS=,100
      X=XMIN
      Y=YMAX+,5/YS
      DO 30 I=1,79
      J=80-I
      IF(ID(J),NE,IBLK) GO TO 40
   30 CONTINUE
      J=1
   40 CALL FCHAR(X,Y,XCS,YCS,0,0)
      WRITE(M,2)(ID(I),I=1,J)
      X=XMIN
      Y=YMAX+,25/YS
      CALL FCHAR (X,Y,XCS,YCS,0,)
      WRITE(M,5) RHO
C
C     DRAW THE Y - AXIS ON THE LEFT SIDE OF THE GRAPH,
C
      IYMAX=YMAX
      IYMIN=YMIN
      IYRAN=IYMAX-IYMIN
      CALL YLOG(XS,YS,XMIN,YMAX,-1,IYRAN)
      CALL LGLBL(XS,YS,XMIN,YMIN,IYRAN,YMIN,1)
C
C     LABEL THE Y - AXIS ON THE LEFT SIDE OF THE GRAPH.
C
      XCS=.15
      YCS=.15
      X=XMIN-.7/XS
      Y=(YMAX-YMIN)/2.0+YMIN-(16.0*XCS)/YS
      CALL FCHAR(X,Y,XCS,YCS,PI/2.)
      WRITE(M,4)
C
C     PLOT THE X AND Y VALUES FOR CHANGE IN MASS SIZE CONCENTRATION
C     (MG/DNM3) VS. GEOMETRIC MEAN DIAMETER (MICROMETERS).
C
   80 KNT=KNT+1
      IV=IV+1
      DO 70 J=1,IV
      IF(DMDLD(J)-GEOMD(J)) 70,70,90
   90 XNEX=ALOG10(GEOMD(J))
      XN=XVAL(XNEX,XMAX,XMIN,XS)
      YNEX=ALOG10(DMDLD(J))
      YN=YVAL(YNEX,YMAX,YMIN,YS)
      CALL PIONT (KNT,XN,YN)
   70 CONTINUE
      IF(ISIG.EQ.0)GO TO 150
C
C     CALL SUBROUTINE JOE2 TO SUPERIMPOSE MASS SIZE DISTRIBUTION AS
C     FOUND FROM DERIVATIVE OF CUMULATIVE MASS LOADING CURVE FIT IF
C     ISIG NOT = 0 HERE.
C
      CALL JOE2
      RETURN
C
  150 CONTINUE
C
C     THIS SUBROUTINE IDENTIFIES THE SET OF DATA PLOTTED WITH THE
C     SYMBOL USED TO DRAW POINTS. (IMPORTANT IF MORE THAN ONE SET OF
C     DATA IS SUPERIMPOSED ON ONE GRID.
C
      CALL LABEL (KNT,XS,YS,YMAX,XMIN)
C
C     RETURN PEN TO "HOME POSITION" AT BASE OF PLOTTER 4.5 INCHES FROM
C     THE MAXIMUM VALUE OF THE X AXIS.. PEN IN THE UP POSITION.
C
      X=XMAX+4.5/XS
      Y=YMIN-2./YS
      CALL FPLOT(-1,X,Y)
    1 FORMAT(1X,*PARTICLE DIAMETER (MICROMETERS)*)
    2 FORMAT(1X,80A1)
    4 FORMAT(1X,*          DM/DLOGD (MG/DNM3)          *)
    5 FORMAT(1X,*RHO = *,F4.2,* GM/CC*)
      RETURN
      END
      SUBROUTINE WALLY3
      INTEGER VV
      DOUBLE PRECISION XNDPEN(10),YO(10)
      DIMENSION IDALL(80),GEMAX(2),GEMIN(2),DMMAX(2),DMMIN(2),DNMAX(2)
      DIMENSION DNMIN(2),DPMAX(2),DPMIN(2),CUMAX(2),CUMIN(2),ID(80)
      DIMENSION DPC(8),CUMG(8),DMDLD(9),GEOMD(9),DNDLD(9)
      COMMON IMPAC,IDALL,RHO1,GEMAX,GEMIN,DMMAX,DMMIN,DNMAX,DNMIN
      COMMON DPMAX,DPMIN,CUMAX,CUMIN,ISIZ1,ISIZ2,ISIZ3
      COMMON IS,NFIT,ID,RHO,DMIN,TKS,POA,FG(5),DMAX,DPC,CUMG,DMDLD
      COMMON GEOMD,DNDLD,GRNAM,MPLOT,DSMA,VV
      COMMON ISIG,XMAX,XMIN,YMAX,YMIN,XS,YS
      COMMON CYC3,MC3,M00,MS
      COMMON XNDPEN
      DATA IBLK/' '/
C
C     THE FOLLOWING VARIABLES ARE  READ INTO WALLY:
C     CG - DN/DLOGD (NO. PARTICLES/DSCM)
C     CH - CUMMULATIVE (GR/ACF).
C     DP - GEOMETRIC MEAN DIAMETER (MICROMETERS)
C     ID - IDENTIFICATION LABEL.
C     RHO - DENSITY
C     MPLOT - CONTROLS THE GRAPHING.
C
      PI=3.1415
      M=7
      N=1
      IF(RHO.EQ.1.0)N=2
C
C     IF MPLOT=1 PLOT NEW GRID ON EACH PASS THROUGH PROGRAM9 IF MPLOT=0 PLOT
C     THE SAME GRID AS PRIVIOUS PLOT.
C
      IF(ISIG.GT.0)GO TO 20
      IF(MPLOT) 80,80,20
   20 KNT=0
C
C     XIN - LENGTH OF THE X AXIS IN INCHES.
C     YIN - LENGTH OF THE Y AXIS IN INCHES.
C
      XIN=4.5
      YIN=6.5
C
C     XMAX - MAXIMUM X VALUE PLOTTED.
C     YMAX - MAXIMUM Y VALUE PLOTTED.
C     XMIN - MINIMUM X VALUE PLOTTED
C     YMIN - MINIMUM Y VALUE PLOTTED.
C
      IF(ISIZ3.EQ.1)GO TO 25
      GO TO (240,241,240,240),IMPAC
  240 YMAX=1.0E15
      YMIN=1.0E06
      GO TO 124
  241 YMAX=1.0E14
      YMIN=1.0E05
  124 XMAX=ALOG10(100.0)
      YMAX=ALOG10(YMAX)
      XMIN=ALOG10(.1)
      YMIN=ALOG10(YMIN)
      GO TO 28
   25 XMAX=ALOG10(100.0)
```

```
      YMAX=SLIM(1,ALOG10(DNMAX(N)))
      XMIN=SLIM(0,ALOG10(GEMIN(N)))
      YMIN=SLIM(0,ALOG10(DNMIN(N)))
C
C     X AND Y SCALE FACTORS CALCULATED HERE.
C
   28 XS=XIN/(XMAX-XMIN)
      YS=YIN/(YMAX-YMIN)
      YORIG=YMIN-2./YS
      CALL SCALF(XS,YS,XMIN,YORIG)
C
C     DRAW THE X - AXIS.
C
      YMIN1=YMIN
      IXMAX=XMAX
      IXMIN=XMIN
      IXRAN=IXMAX-IXMIN
      CALL XSLBL(XS,YS,XMIN,YMIN1,IXRAN,XMIN)
      CALL XLOG(XS,YS,XMAX,YMIN1,-1,IXRAN)
C
C     LABEL THE X - AXIS.
C
      XCS=.15
      YCS=.15
      X=((XMAX-XMIN)/2.0)+XMIN-(16.0*XCS)/XS
      Y=YMIN1-(.7/YS)
      CALL FCHAR (X,Y,XCS,YCS,0.)
      WRITE(M,1)
C
C     WRITE THE ID LABELS.
C
      XCS=.056
      YCS=.100
      X=XMIN
      Y=YMAX+.5/YS
      DO 30 I=1,79
      J=80-I
      IF(ID(J).NE.IBLK) GO TO 40
   30 CONTINUE
      J=1
   40 CALL FCHAR(X,Y,XCS,YCS,0.0)
      WRITE(M,2)(ID(I),I=1,J)
      X=XMIN
      Y=YMAX+.25/YS
      CALL FCHAR (X,Y,XCS,YCS,0.)
      WRITE(M,5) RHO
C
C     DRAW THE Y - AXIS ON THE LEFT SIDE OF THE GRAPH.
C
      IYMAX=YMAX
      IYMIN=YMIN
      IYRAN=IYMAX-IYMIN
      CALL YLOG(XS,YS,XMIN,YMAX,-1,IYRAN)
      CALL LGLBL(XS,YS,XMIN,YMIN,IYRAN,YMIN,1)
C
C     LABEL THE Y - AXIS ON THE LEFT SIDE OF THE GRAPH.
C
      XCS=.15
      YCS=.15
      X=XMIN-.7/XS
      Y=((YMAX-YMIN)/2.0)+YMIN-(16.0*XCS)/YS
      CALL FCHAR(X,Y,XCS,YCS,PI/2.)
      WRITE(M,4)
C
C     PLOT X AND Y VALUES FOR CUMMULATIVE(MG/ACM VS D50'S.
C
   80 KNT=KNT+1
      IV=VV+1
      DO 70 J=1,IV
      IF(DNDLD(J)*GEOMD(J))70,70,90
   90 XNEX=ALOG10(GEOMD(J))
      XN=XVAL(XNEX,XMAX,XMIN,XS)
      YNEX=ALOG10(DNDLD(J))
      YN=YVAL(YNEX,YMAX,YMIN,YS)
      CALL PIONT (KNT,XN,YN)
   70 CONTINUE
C
      IF(ISIG.EQ.0)GO TO 150
C
      CALL JOE2
      RETURN
C
  150 CONTINUE
      CALL LABEL(KNT,XS,YS,YMAX,YMIN)
      X=XMAX+4.4/XS
      Y=YMIN-2./YS
      CALL FPLOT(+1,X,Y)
   60 RETURN
    1 FORMAT(1X,'PARTICLE DIAMETER (MICROMETERS)')
    2 FORMAT(1X,80A1)
    4 FORMAT(1X,'  DN/DLOGD NO.PARTICLES/DNM3)  ')
    5 FORMAT(1X,'RHO = ',F4.2,' GM/CC')
      END
      SUBROUTINE XLOG(XS,YS,X0,Y0,K,L)
C  PEN MAY BE UP OR DOWN.
C  XS = X-SCALE FACTOR,  INCHES/USER'S UNIT
C  YS = Y-SCALE FACTOR,  INCHES/USER'S UNIT
C  Y0 = STARTING Y-VALUE WITH RESPECT TO ORIGIN.
C  X0 = STARTING X-VALUE WITH RESPECT TO ORIGIN.
C  K = +1, FOR POSITIVE X-DIRECTION
C  K = -1, FOR NEGATIVE X-DIRECTION
C  L = NUMBER OF LOG10 CYCLES
      P=0.05/YS
      Q=0.075/YS
      XK=FLOAT(K)
      TEST=X0+XK*FLOAT(L)
      LIMIT=L+1
      CALL FPLOT(-2,X0,Y0)
      DO 300 J=1,LIMIT
      XI=X0+XK*FLOAT(J-1)
      CALL FPLOT(0,XI,Y0)
      CALL FPLOT(0,XI,Y0-Q)
      CALL FPLOT(0,XI,Y0+Q)
      CALL FPLOT(0,XI,Y0)
      CALL FPLOT(0,XI,Y0)
      IF(XI-TEST)250,300,250
  250 DO 300 I=1,8
      IF(K)260,300,270
  260 YI=10-I
      GO TO 280
  270 YI=I
  280 YI=1.0+1.0/YI
      XI=XI+XK*ALOG10(YI)
      CALL FPLOT(0,XI,Y0)
      CALL FPLOT(0,XI,Y0-P)
      CALL FPLOT(0,XI,Y0+P)
      CALL FPLOT(0,XI,Y0)
      CALL FPLOT(0,XI,Y0)
  300 CONTINUE
      CALL FPLOT(1,XI,Y0)
      RETURN
      END
      SUBROUTINE XSLBL(XS,YS,X0,Y0,L,E)
C CAN ONLY LABEL FROM -9 TO +9
C  (X0,Y0) ARE THE COORDINATES CORRESPONDING TO THE FIRST LOG CYCLE TO
C   BE IDENTIFIED.
C  PEN MAY BE UP OR DOWN
C  THE IDENTIFICATION IS BELOW THE X-AXIS
C  XS = X-SCALE FACTOR, INCHES/USER'S UNITS
C  YS = Y-SCALE FACTOR, INCHES/USER'S UNITS
C  X0 = INITIAL X-VALUE.
C  Y0 = INITIAL Y-VALUE.
C  L = NUMBER OF LOG10 CYCLES
C  E = EXPONENT OF FIRST CYCLE +,0,-
    1 FORMAT(' 10')
    2 FORMAT(1X,I2)
      LIMIT=L+1
      DO 100 I=1,LIMIT
      XN=X0+FLOAT(I-1)
      IXN=E+FLOAT(I-1)
      XN=XN-0.2/XS
      YN=Y0-0.3/YS
      CALL FCHAR(XN,YN,       0.15,0.15,0.0)
      YN=Y0-0.2/YS
      WRITE(7,1)
      XNE=XN+0.2/XS
      IF(IXN) 50,60,60
   50 XNE=XN+0.3/XS
   60 CALL FCHAR(XNE,YN,      0.1,0.1,0.0)
      WRITE(7,2) IXN
  100 CONTINUE
      RETURN
      END
      FUNCTION XVAL(X1F,AMAX,AMIN,AS)
C
C
C     THIS FUNCTION GIVES A VALUE TO DPC (I.E. XN)
C     SUCH THAT IT WILL BE PLOTTED JUST BEYOND THE
C     GRAPH BOUNDARY IF > XMAX OR < XMIN.
C
C
      IF(X1F-AMAX)87,87,86
   86 XVAL=AMAX+.15/AS
      RETURN
   87 IF(AMIN-X1F)89,89,88
   88 XVAL=AMIN-.15/AS
      RETURN
   89 XVAL=X1F
      RETURN
      END
      SUBROUTINE  YLOG(XS,YS,X0,Y0,K,L)
C
C  PEN MAY BE UP OR DOWN
C  YS = Y-SCALE FACTOR,  INCHES/USER'S UNIT
C  XS = X-SCALE FACTOR,  INCHES/USER'S UNIT
C  Y0 = STARTING Y-VALUE WITH RESPECT TO ORIGIN.
C  X0 = STARTING X-VALUE WITH RESPECT TO ORIGIN.
C  K = +1, FOR POSITIVE Y-DIRECTION
C  K = -1, FOR NEGATIVE Y-DIRECTION
C  L = NUMBER OF LOG10 CYCLES
C
      P=0.05/XS
      Q=0.075/XS
      XKC=0.4342944819*FLOAT(K)
      L=L+1
C
      CALL FPLOT(-2,X0,Y0)
      DO 300 J=1,L
      YI=Y0+FLOAT(K*(J-1))
      N=1
      X=Q
  200 DO 250 I=1,N
      IF(N-1) 210,240,210
  210 IF(K) 220,300,230
  220 XI=10-I
      GO TO 235
  230 XI=I
  235 YI=YI+XKC*ALOG(1.0+1.0/XI)
  240 CALL FPLOT(0,X0,YI)
      CALL FPLOT(0,X0-X,YI)
      CALL FPLOT(0,X0+X,YI)
      CALL FPLOT(0,X0,YI)
  250 CALL FPLOT(0,X0,YI)
      IF(J-L) 255,300,300
  255 IF(N-1) 300,260,300
  260 N=8
      X=P
      GO TO 200
  300 CONTINUE
      L=L-1
C
      RETURN
      END
      SUBROUTINE YPROB(XS,YS,X,KODE,IMIN,IMAX)
C
C        PLOT AND LABEL Y AXIS FOR NORMAL PROBABILITY SCALE
C        GASTON-19DEC1975.
C
C        Y AXIS AT XMIN IS LABELLED DOWN FROM YMAX = 99.99
C        TO YMIN = 0.01 ON THE LEFT OF THE AXIS.
C
C        Y AXIS AT XMAX IS LABELLED DOWN FROM YMAX = 0.01 TO
C        YMIN = 99.99 ON THE RIGHT OF THE AXIS.
C
C        XS = X SCALE FACTOR IN INCHES/UNIT
C        YS = Y SCALE FACTOR IN INCHES/UNIT
C        X = Y AXIS X VALUE INDICATED BY KODE
C        KODE = 0 FOR X = XMIN, LABEL TO LEFT OF AXIS
C        KODE = NON-0 FOR X = XMAX, LABEL TO RIGHT OF AXIS
C
C        DO THE FOLLOWING SEQUENCE IN MAIN PROG TO SET UP
C         SCALE FACTOR FOR Y PROBABILITY AXIS.
C
C         NDTRI COMPUTES A Y VALUE FOR A GIVEN PROBABILITY
C         CALL NDTRI(0.9999,YMAX,D,IE)   NDTRI FROM 360 SSP.
C         CALL NDTRI(0.0001,YMIN,D,IE)
C         YS = YINCH/(YMAX-YMIN)
C         XS = WHATEVER X SCALE USED
C         CALL SCALF(XS,YS,XMIN,YMIN)
C
C        MOVE PEN TO XMIN OR XMAX,YMIN BEFORE CALLING YPROB
C
      DIMENSION BTV(25),STI(25),NST(25)
C
C        BTV IS ARRAY OF BIG TICK MARK Y PROBABILITY VALUES
C
      DATA BTV/0.0001,.0005,.001,.002,.005,.01,.02,
     2         .05,.1,.2,.3,.4,.5,.6,.7,.8,.9,.95,
     3         .98,.99,.995,.998,.999,.9995,.9999/
C
C        STI IS ARRAY OF SMALL TICK MARK PROBABILITY INCREMENTS
C
      DATA STI/0.0001,.0001,.0005,.001,.001,.002,.01,.01,
     2         .01,.02,.02,.02,.02,.02,.02,.01,.01,.01,
     3         .002,.001,.001,.0005,.0001,.0001,0./
C
C
C        NST IS ARRAY OF NUMBER OF SMALL TICKS BETWEEN BIG TICKS
C
      DATA NST/3,4,1,2,4,4,2,4,9,4,4,4,4,4,4,9,4,
     2         2,4,4,2,1,4,3,0/
C
C        BIG AND SMALL TICK MARK LENGTHS
C
      BTL = 0.075/XS
      STL = 0.05/XS
C
C        PLOT Y AXIS WITH BIG AND SMALL TICK MARKS GOING UP
C         FROM XMIN OR XMAX TO YMAX.
C
      DO 50 I=IMIN,IMAX
      Y1 = BTV(I)
      CALL NDTRI(Y1,Y,D,IE)
      CALL FPLOT(-2,X,Y)
      CALL FPLOT(0,X+BTL,Y)
      CALL FPLOT(0,X-BTL,Y)
      CALL FPLOT(0,X,Y)
      K = NST(I)
      IF(I.EQ.IMAX)GO TO 60
      DO 50 J=1,K
      Y2 = Y1 + J*STI(I)
      CALL NDTRI(Y2,Y,D,IE)
      CALL FPLOT(0,X,Y)
      CALL FPLOT(0,X+STL,Y)
      CALL FPLOT(0,X-STL,Y)
      CALL FPLOT(0,X,Y)
   50 CONTINUE
C
C        X WIDTH AND Y HEIGHT OF LABELLING CHARACTERS
C
   60 XCS = 0.15
      YCS = 0.15
C
C        START LABELLING LOOP
C         LABELLING IS DOWN THE AXIS TO THE LEFT IF KODE IS 0
C         AND TO THE RIGHT IF KODE IS NON-0.
C
      L=0
      DO 200 I=IMIN,IMAX
      L=L+1
      J=IMAX-L+1
      P = BTV(J)
      CALL NDTRI(P,Y,D,IE)
      Y = Y - (YCS/2.)/YS
      IF( KODE ) 85,80,85
   80 P = P*100.
      IF( J - 24 ) 100,90,90
   85 XP = X + (XCS/XS)
      P = BTV(L)*100.
      IF( L - 2 ) 185,185,105
C
C         99.99,99.95
C
   90 XP = X - (6.*XCS)/XS
   95 CALL FCHAR(XP,Y,XCS,YCS,0.)
      WRITE(7,1) P
    1 FORMAT(1X,F5.2)
      GO TO 200
C
C         99.9,99.8,99.5
C
  100 IF( J - 21 ) 120,110,110
  105 IF( L - 5 ) 175,175,125
  110 XP = X - (5.*XCS)/XS
  115 CALL FCHAR(XP,Y,XCS,YCS,0.)
      WRITE(7,2) P
    2 FORMAT(1X,F4.1)
      GO TO 200
C
C         99-10
C
  120 IF( J - 9 ) 140,130,130
  125 IF( L - 8 ) 155,155,145
  130 XP = X - (3.*XCS)/XS
  135 IP = P+0.5
      CALL FCHAR(XP,Y,XCS,YCS,0.)
      WRITE(7,3) IP
    3 FORMAT(1X,I2)
      GO TO 200
C
C        5,2,1
C
  140 IF( J - 6 ) 160,150,150
  145 IF( L - 20 ) 135,135,165
  150 XP = X - (2.*XCS)/XS
  155 IP = P
      CALL FCHAR(XP,Y,XCS,YCS,0.)
      WRITE(7,4) IP
    4 FORMAT(1X,I1)
      GO TO 200
C
C        0.5,0.2,0.1
C
  160 IF( J - 3 ) 180,170,170
  165 IF( L - 23 ) 115,115,95
  170 XP = X - (4.*XCS)/XS
  175 CALL FCHAR(XP,Y,XCS,YCS,0.)
      WRITE(7,5) P
    5 FORMAT(1X,F3.1)
      GO TO 200
C
C        0.05,0.01
C
  180 XP = X - (5.*XCS)/XS
  185 CALL FCHAR(XP,Y,XCS,YCS,0.)
      WRITE(7,6) P
    6 FORMAT(1X,F4.2)
  200 CONTINUE
      RETURN
      END
      FUNCTION YVAL(Y1F,BMAX,BMIN,BS)
C
C
C     THIS FUNCTION GIVES A VALUE TO CUMG (I.E. YN)
C     SUCH THAT IT WILL BE PLOTTED JUST BEYOND THE
C     GRAPH BOUNDARY IF > YMAX OR < YMIN.
C
C
      IF(Y1F-BMAX)97,97,96
   96 YVAL=BMAX+.15/BS
      RETURN
   97 IF(BMIN-Y1F)99,99,98
   98 YVAL=BMIN-.15/BS
      RETURN
   99 YVAL=Y1F
      RETURN
      END
```

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APPENDIX

PLOTTING SOFTWARE FOR THE DIGITAL EQUIPMENT CORPORATION PDP-15/76

Digital Equipment Corporation, (DEC) PDP-15/76 Plotter Subroutines

This Appendix describes relocatable plotter subroutines for the DEC PDP-15/76 computer system. These subroutines can be used to draw and scale grid lines, to draw special point characters, to draw alphameric characters at various angles, and to plot curves, graphs, charts, and maps. The subroutines can be used in FORTRAN language programs.

The unichannel XY plotter handler is also included. This document explains the responses of the plotter (an IBM 1627) to WRITE and READ commands of the DEC Input Output Programming System (IOPS) and IOPS American Standard Code Information Interchange (ASCII) modes.

GENERAL

When connected to a DEC PDP-15/76 computing system, the IBM 1627 plotter can be programmed to produce bar charts, organization charts, engineering drawings, maps, or special curves. This Appendix describes a set of subroutines, written in assembler language, used to control the plotter. These subroutines can also be called from a FORTRAN language program.

PLOTTER CHARACTERISTICS

Chart paper width	12 inches
Plotting width	11 inches
Chart paper length	120 feet
Plotting length	120 feet
Incremental step size	1/100 inch
Step speed	up to 18,000 steps/min
Pen status change	600 operations/min

X-axis movement is produced by rotating the chart paper on the drum under the pen. Rotating the drum down causes the pen to draw a line, effectively, in the up direction; this movement is the positive X-axis motion. Rotating the chart paper up produces the negative X-axis motion. X-axis movement is caused by moving the pen parallel to the drum axis. When looked at from the front of the plotter, the positive Y-axis motion is to the left; the negative, to the right.

Thus, the length of the X-axis is limited by the length of the roll of chart paper, and the length of the Y-axis is determined by the paper's width. Various combinations of paper and pen movement with the pen up or down are utilized to produce the desired drawings.

PLOTTER CAPABILITIES

The plotter generates all lines by using a series of incremental straight line segments. The increment length is 0.01 inch, drawn in either a positive or negative direction, parallel to either the X-axis of the Y-axis. Also, the paper and pen can be moved simultaneously to produce line increments at a 45° angle to either axis in either direction. This results in a diagonal line connecting opposite corners of an X-Y square. Combinations of increments at various angles can closely approximate any desired curve.

Preciseness of lines and characters depends on the size of the pen point and the scale selected by the programmer.

Graphs, curves, charts, etc., can be developed by programming the appropriate instructions to the plotter.

Because of the relative slowness of the plotter, compared with the computer, the plotter system has a buffering scheme which holds plotter instructions until they are executed. This leaves the computer free to do other jobs while the actual plotting is being completed.

SUBROUTINE FUNCTIONS

There are six primary functions of the plotter subroutines described in this manual.

SCALE: Accepts and stores scaling information required by the grid, plot, and character functions.

GRID: Draws a line with scaled grid marks.

PLOT: Moves the pen from its present position to a new position. It can also raise or lower the pen either before or after the traverse movement.

POINT: Draws a special point character at the present location of the pen, if the pen is down. The point characters available are +, X,□ , O, and blank. All point characters are fixed in size.

CHARACTER: Positions the pen for annotation and provides character size and angle information.

ANNOTATION: Forms the characters to be plotted from computer output data. Characters available are those in the FORTRAN character set.

INPUT FORMAT

The input data to the subroutines can be either in double or standard precision format, but different subroutines are required for each precision, with the exception of the point subroutine. For example, to perform the plot function in standard precision, the FPLOT subroutine is used; for double precision, the EPLOT subroutine is used. Standard precision uses two 18-bit words to form a constant or variable, while double precision uses three 18-bit words for the same constant or variable.

SCALE

The scale subroutine accepts and stores scaling information required by the grid, plot, and character functions.

If the scale subroutine is not called, the plot subroutine assumes initial scale values of one inch per unit along both axes and establishes the origin (intersection of the X-axis and the Y-axis) at the present pen position. However, the scale subroutine must be called to define other scale factors and to establish the origin at other points. The scale subroutine can be called as often as required to redefine the scaling values and the origin position.

Each time the scale subroutine is called, the origin established is based on the physical location of the pen. Therefore, the pen must be moved to the position assumed by the subroutine before the subroutine is called. Also, the pen position cannot be moved more than 163.83 inches in either X direction from its physical location at the time the origin was last established.

Scale values are given in inches per unit of the using program. For example, to indicate a scale of 1/4 inch equal to 1 foot, the scale value would be 0.25. To indicate a scale of

1 inch equal to 10 years, the scale would be 0.1. Different scale values can be assigned to the X axis and the Y axis.

The pen is usually aligned by reticle adjustment to some point on the chart paper. The scale subroutine establishes the origin at any desired point relative to the physical location of the pen when the subroutine is called. Therefore, or until the origin is moved, all measurements are calculated from this origin to prevent an accumulation of errors which would result from measuring from point to point with calculated values that have been rounded off or truncated.

The values inserted by this subroutine are positive or negative as measured perpendicularly from each desired axis to the present location of the pen.

FORTRAN

Standard precision: CALL SCALF (X_s, Y_s, X_o, Y_o)

Double precision: CALL SCALE (X_s, Y_s, X_o, Y_o)

X_s is a real constant or variable that defines the number of inches per user's unit to be used along the X-axis.

Y_s is a real constant or variable that defines the number of inches per user's unit to be used along the Y-axis.

X_o is a signed real constant or variable that specifies the X value of the present position of the pen relative to the desired origin, measured in user's units.

Y_o is a signed real constant or variable that specifies the Y value of the present position of the pen relative to the desired origin, measured in user's units.

GRID

The grid subroutine plots a straight line parallel to either the X- or the Y-axis in a positive or a negative direction with tick marks at regularly spaced intervals. The tick marks are 0.10-inch long, with one-half the mark on each side of, and perpendicular to, the grid line. The programmer must specify the starting point, the direction to be plotted, how far to go, and the distance between tick marks.

It is not required to know either the location of the pen or whether it is up or down when this subroutine is called. At the end of the subroutine, the pen is left in the up position.

FORTRAN

```
Standard precision:  CALL FGRID (I, X, Y, U, N)
  Double precision:  CALL EGRID (I, X, Y, U, N)
```

I is an integer constant or variable that specifies the direction the grid line is to be generated as follows:

I = 0 specifies the +X direction
I = 1 specifies the +Y direction
I = 2 specifies the -X direction
I = 3 specifies the -Y direction

X is a signed real constant or variable that specifies the X value of the grid line starting point, measured in the user's units.

Y is a signed real constant or variable that specifies the Y value of the grid line starting point, measured in the user's units.

U is a real constant or variable that specifies the distance between tick marks, measured in the user's units.

N is an integer constant or variable that defines the length of the grid line. N is equal to the number of tick marks minus one, and must be less than 131,072.

PLOT

This subroutine is called to move the pen from its present position to a new position. It is the user's responsibility to check that the coordinates of the new position are within limits. The pen can also be raised or lowered before or after the traverse movement, as a part of this subroutine.

FORTRAN

```
Standard precision:  CALL FPLOT (I, X, Y)
  Double precision:  CALL EPLOT (I, X, Y)
```

I is an integer expression controlling the pen as follows:

I = 0 no change
I is positive, control pen before movement
I is negative, control pen after movement
I is odd, raise pen
I is even, lower pen

X is a signed real constant or variable defining the X value of the new position, measured in the user's unit.

Y is a signed real constant or variable defining the Y value of the new position, measured in the user's units.

POINT

The point subroutine draws special point characters at the present position of the pen. The pen must be down when this subroutine is called.

This subroutine assumes the pen is down and leaves the pen down when finished. Each point character is inscribed within a 0.10-inch square.

FORTRAN

```
CALL POINT (I)
```

I is an integer expression that defines the character to be drawn as follows:

$I < 0$	blank
$I = 0$	+
$I = 1$	x
$I = 2$	□
$I = 3$	O

CHARACTER

This subroutine is used to initialize the annotation subroutine by establishing the height and width of characters, the angle (relative to the X-axis) they are drawn, and the starting location. Calling this subroutine also raises the pen (if down) and moves the pen to the specified starting location. The height and width parameters determine a rectangle inside of which each character is drawn. The annotation subroutine remains initialized by the call to this subroutine until a new call supersedes the old one.

FORTRAN

Standard precision: CALL FCHAR (X_n, Y_n, X_s, Y_s, THETA)

Double precision: CALL ECHAR (X_n, Y_n, X_s, Y_s, THETA)

X_n is a signed real variable or constant defining the X value (user's units) of the starting location.

Y_n is a signed real variable or constant defining the Y value (user's units) of the starting location.

X_s is an unsigned real variable or constant defining the width of the character, expressed in inches. A value exceeding two decimal places will be rounded off to the nearest 0.01.

Y_s is an unsigned real variable or constant defining the height of the character, expressed in inches. A value exceeding two decimal places will be rounded off to the nearest 0.01.

THETA is a signed real variable or constant defining the angle at which the character (or line of characters) is to be drawn, expressed in radians. Theta is measured by rotating a line parallel to the X-axis about the starting location. Positive values produce counterclockwise rotation; negative values, the opposite.

Due to the physical resolution limitation of the plotter, it is impossible to rotate a character through all angles. The possible angles are discrete and are a function of the particular character being rotated and the angle of rotation. Thus, there may be a discrepancy between Theta and the actual plotted angle of rotation, which will be most significant for small character sizes. The same phenomenon will also cause distortion of the character shape in many cases.

When using the annotation routine to plot a string of rotated characters, the rotational inaccuracies in each character will accumulate and may produce distorted lines. The accumulative effect may be overcome by drawing the line one character at a time and using ECHAR or FCHAR to position each character in its proper location.

ANNOTATION

This subroutine forms the characters specified by computer output data to the parameters established by the character subroutine. These parameters determine a rectangle inside of which each character is drawn. The starting location is the lower left corner of the rectangle. In a continuous row of characters, the starting location is the lower left corner of the first character. When the last character is completed, this subroutine stops the pen in the up position over the lower left corner of the next character position in sequence. Repetitive lines are plotted end to end. The character set available is the FORTRAN character set.

FORTRAN

WRITE (I, FORMAT) list

I is an integer that specifies the logical unit number of the I/O unit (plotter) to be used for output data. I must be 7.

FORMAT is a statement number of the FORMAT statement describing the type of data conversion to be performed between the internal and external representation of each quantity in the list. Each FORMAT statement must contain a carriage control indicator (1X).

LIST is a list of variable names, separated by commas, which represent the output data.

XLOG

This subroutine draws the X-axis for log$_{10}$ scale. The pen may be up or down when the subroutine is called.

FORTRAN

```
CALL XLOG (XS, YS, X0, Y0, K, L)
```

XS is a real, standard precision constant or variable which defines the X-scale factor in inches per user's unit.

YS is a real, standard precision constant or variable which defines the Y-scale factor in inches per user's unit.

X0 is a real, standard precision constant or variable which defines the starting X-value with respect to the origin.

Y0 is a real, standard precision constant or variable which defines the starting Y-value with respect to the origin.

K = +1 for the positive X direction; K = -1 for the negative X direction.

L is the number of log$_{10}$ cycles.

XSLBL

This subroutine labels the X-axis for log$_{10}$ scale. The pen may be up or down when the subroutine is called.

FORTRAN

```
CALL XSLBL (XS, YS, X0, Y0, L, E)
```

XS is a real, standard precision constant or variable which defines the X-scale factor in inches per user's unit.

YS is a real, standard precision constant or variable which defines the Y-scale factor in inches per user's unit.

X0 is a real, standard precision constant or variable which defines the initial X value.

Y0 is a real, standard precision constant or variable which defines the initial Y value.

L is the number of $\log_{10}$ cycles.

E is the exponent of the first cycle.

YLOG

This subroutine draws the Y-axis for $\log_{10}$ scale. The pen may be up or down when the subroutine is called. All real variables must be standard precision.

FORTRAN

```
CALL YLOG (XS, YX, X0, Y0, K, L)
```

XS is the X-scale factor in inches per user's unit.

YS is the Y-scale factor in inches per user's unit.

X0 is the starting X value with respect to the origin.

Y0 is the starting Y value with respect to the origin.

K = +1 for positive Y direction; K = -1 for negative Y direction.

L is the number of $\log_{10}$ cycles.

LGLBL

This subroutine labels the Y-axis for $\log_{10}$ scale. The pen may be up or down when the subroutine is called. All real variables must be standard precision.

FORTRAN

CALL LGLBL (XS, YS, X0, Y0, L, E, K)

XS defines the X-scale factor in inches per user's unit.
YS defines the Y-scale factor in inches per user's unit.
X0 is the initial X value.
Y0 is the initial Y value.
L is the number of $\log_{10}$ cycles.
E is the exponent of the first cycle.
K = 0 for labeling on the right side of the Y-axis;
K = 1 for labeling on the left side of the Y-axis.

NOTES:

1. 1X is required as first character in format of formatted writes to plotter.
2. Must have a CALL CLOSE (7) after the last plotter instruction in the program to get the last few plot commands to the plotter. No CALL CLOSE (7) is required if there are no plot commands in the job.
3. Turning the plotter off results in lost plots.

```
CALL SCALE
                    (XS,YS,X0,Y0)
CALL SCALF
                   Scale                 Initial position
                   factor in             in user's units
                   inches per
                   user's unit


CALL EGRID
                   (I,X,Y,U,N)
CALL FGRID
              Direction     Grid line     User's      Number of
              0 = +X        starting      units       tick marks
              1 = +Y        point in      per tick    less one
              2 = -X        user's units
              3 = -Y


CALL EPLOT
                     (I,XN,YN)
CALL FPLOT
                  Pen control                     New position in
                  0   No change                   user's units
                  +   Control before steps
                  -   Control after steps
                Odd   Raise pen
               Even   Lower pen


CALL ECHAR
                     (XN,YN,XS,YS,THETA)
CALL FCHAR
              Starting      Width of     Height of    Angle at which
              location in   character    character    character is to
              user's units  in inches    in inches    be drawn


WRITE (I, FORMAT)  LIST

       I = 7

CALL POINT (I)

       I < 0    blank
       I = 0    +
       I = 1    x
       I = 2    □
       I = 3    O
```

UNICHANNEL XY PLOTTER HANDLER

The XY Plotter responds to WRITE commands of the IOPS Binary and IOPS ASCII modes. The IOPS Binary mode is used for initializing the handler, drawing lines or drawing characters, while the IOPS ASCII mode is used only to draw characters.

The terms "absolute" coordinates and "delta" coordinates are used below. Absolute coordinates are coordinates determined by a READ (7) operation, (LASTX, LASTY). When one moves to some new set of coordinates, (LASTX + ΔX, LASTY + ΔY), the ordinate and abscissa of the shift (ΔX, ΔY) are the "delta" coordinates.

FORMAT OF IOPS BINARY WRITES (FROM FORTRAN):

WRITE (7) mode (followed by optional variables, depending on the value of mode).

Mode		Additional variables
0	Pick up the pen	None
1	Put down the pen	None
2	Move to absolute coordinates. Address with pen up	IX, IY
3	Move to absolute coordinates. Address with pen down	IX, IY
4	Move to delta coordinates. Address with pen up	IX, IY
5	Move to delta coordinates. Address with pen down	IX, IY
6	Draw character (see note below)	ICNT, DATA
7	Set coordinate address	IX, IY
8	Move to absolute coordinate address (no pen change)	IX, IY
9	Move to delta coordinate address (no pen change)	IX, IY
10	Set character attributes	IXSIZ, IYSIZ, ISIN, ICOS

FORMAT OF IOPS ASCII WRITES (FORTRAN): Normal FORMAT statements, see Note 12. Characters can be written from IOPS Binary.

NOTES:

1. The pen actions (explicit or implicit) check to see if the pen is currently up or down, and suppresses redundant moves.
2. When the handler is first called (i.e., start of program), the pen is up; the coordinates address is (0,0); the character scale is 20X20 plotter steps; and the characters are not rotated.
3. Characters are drawn on a 9X11 matrix with 2 spaces between characters giving a basic character box size of 10X10.
4. IXSIZ and IYSIZ are plotter steps for the desired character size. The minimum value of IXSIZ or IYSIZ is 0.01 inch.
5. The character may be rotated by specifying the sin and cos of the angle of rotation. The values must be integer and scaled by 65536 (i.e., ISIN = 65536*(SIN(THETA)).
6. Character writes use the values of the last scale and rotation values.
7. "Interface Routines" may be written in FORTRAN to emulate any plotter package. Consider a routine which draws a line with the pen down by specifying delta X and Y values. One would write a FORTRAN subroutine, such as this one to replace the old one:

```
SUBROUTINE LINE (IX,IY)
DATA MODE/5/
WRITE (7) MODE, IX,IY
RETURN
END
```

8. Only the IBM 1130 FORTRAN 48 character set is presently implemented. No percent symbol (%) is available.

9. Only rectangular characters may be obtained.
10. Powering down the plotter does not cause an error, but plots will be lost.
11. READ (7) LASTX, LASTY, ISX, ISY, ISIN, ICOS, IPEN

    LASTX and LASTY are previous pen position (absolute coordinates).

    ISX and ISY are last character sizes.

    ISN and ICOS are last sin and cos of character angle.

    Cos 0° = 65536.

    IPEN = 0 if pen is up, 10000 (octal) if pen is down.
12. The first character in a FORMAT statement is not plotted. One should use 1X or leave one blank space.
13. Binary characters for a mode 6 WRITE should be A5 ASCII.